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IMPACTS OF WATER SCARCITY ON COAST GUARD MISSION REQUIREMENTS A--ETC(U)

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IMPACTS OF WATER SCARCITY ON COAST GUARD MISSION REQUIREMENTS AND PERFORMANCE

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APRIL 1981

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16. Abstract

The objectives of the study were to identify the technological impacts of water scarcity, and to assess the impacts of such technology on the Coast Guard's mission requirements and mission performance. Based on the assumption used in this study that water will become a scarce resource in the future, a series of scenarios were developed which identified and analysed the factors leading to water scarcity and the consequences that arise by increasing awareness of that scarcity.

The work included detailed investigations into: (1) water supply (iceberg towing, desalination, weather modification, and groundwater); (2) water demand (irrigation, industry use, power plants, and hydropower generation); (3) contributing factors (pollution controls, waste disposal, water conservation devices, water reuse and recycle, and water storage and transfer; (4) Federal, state and local policy and water management programs; and (5) USCG mission and programs.

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EXECUTIVE SUMMARY

This report considers the possible effects of long-term, pervasive water scarcity on the Coast Guard's mission through about the year 2000. Such a scarcity of water might have a significant impact on several elements of the Coast Guard mission, depending on the measures adopted to provide additional supplies and on the geographic location and the nature of specific physical (essentially geologic and hydrologic) effects.

The Prospect of Water Scarcity

Americans are becoming increasingly aware of the finite nature of many natural resources. We have in recent years become dependent on foreign sources for petroleum, natural gas, and many minerals. But not all U. S. resources are in short supply. Agricultural products, for example, are abundant, and agricultural exports have mitigated significantly the negative effects of energy and mineral imports. The recovery, processing, transport, and use of most resources, along with the performance of a vast complex of domestic, municipal, and industrial activities, are all linked to the basic and most common resource--water.

On the whole, the United States has abundant water resources. An average of 4200 billion gallons per day (BGD) falls on the continental United States as rain, snow, and other forms of precipitation; of this, 1450 BGD are stored (as groundwater, in natural and manmade lakes, etc.), flow to the

sea, or are consumed by man. The remainder returns to the atmosphere by evapotranspiration.

Though available U.S. water supplies are large, shortages have occurred locally throughout our history, varying considerably in duration and severity. Such shortages--or longer-term, more extensive scarcities--can result from increased demand as populations and their needs grow, from decreases in supply through drought or excessive withdrawals, or through combinations of these factors.

Some regions of the U.S. are inherently water deficient, such as the semi-desert Southwest and the extensive regions on the lee sides (generally east) of major mountain ranges, and other regions are inherently water-rich, such as the Pacific Northwest and most regions east of the Mississippi. Regions where water demand and withdrawal rates for agricultural, domestic, and industrial uses, are very high, or where pollution and contamination are severe and widespread (commonly both conditions exist concurrently and are interrelated), may also be "water short" even though precipitation and accumulation may be relatively large.

By the year 2000, consumptive uses of water (i.e., water removed permanently from the water supply) are expected to increase by nearly 30% as a result of growth in manufacturing, mineral industries, steam electric generation, agriculture, and the needs of growing populations. This increase in consumptive use, particularly if combined with severe and persistent drought, is likely to result in water scarcity over significant

portions of the United States. It is estimated that as much as 25% of the U. S. land area and 18% of its population face water scarcity during the next two decades related to combinations of factors such as discussed above occurring within particular drainage regions.

The most significant impacts of such scarcity on the Coast Guard mission are likely to be associated with two general areas of response to the scarcity problem: (1) resolution of problems related to commercial traffic, pollution and contaminations, and other uses and abuses of the inland, estuarine, and coastal waterway systems, and (2) technologies adopted to mitigate the water shortages.

Water Scarcity and the Navigable Waterways

The Nation's navigable waterway systems consists of 26,700 miles of inland and intracoastal waterways, about 65% of them with authorized channel depths of 9 feet. These navigable channels and canals provide direct access to 131 of the Nation's largest cities and to almost all parts of the continental United States. This sytem of navigable waterways is very important to the Nation's economy, carrying about one-fourth of the total intercity freight (although this totals only about 17% of the net tonnage carried). The largest and most improved of the navigable inland waterways is that part of the system formed by the Mississippi River and its tributaries, with 9,000 miles of commercial channels. The Atlantic Intracoastal Waterway and the New York-New England System add 7,000 miles of navigable channels; the Gulf Intracoastal Waterway totals 5,400 miles;

and the Columbia-Snake River systems and the Central California System (San Francisco Bay and inland) together add another 3,600 miles.

Widespread, persistent water scarcity caused by drought or by the expected great increase in withdrawals, from both surface and groundwater, for industrial, power development, agricultural, and human domestic uses could result in substantial lowering of water levels in the navigable inland and estuarine waterways. The Coast Guard mission is vitally bound to commerce on the inland waterways, including aids to navigation; traffic control; bridge administration; pollution and hazardous material spill prevention, containment, and clean-up; firefighting; and safety, including both recreational boating safety and the safety and security of vessels.

The width and depth of navigable channels, and of the total water-course, change with the river stage, and current velocity also fluctuates with changes in stage. As a result, channels shift and may be narrowed, channel depths may decrease, and sandbars are built or destroyed; thus, channel buoys must be shifted, dredging activity must be increased, and traffic control is affected. Spills and leakage are increasingly likely under conditions in which channel depths are decreased, and tank carriers are more likely to contact the bottom or strike bars or other obstacles exposed by lowered water levels.

The amount of hazardous cargo transported by water is likely to continue to increase, and new hazardous products will appear. As noted in the 1971 Coast Guard report on Ports and

Waterways, the chemical industry in this country, which produces most of the hazardous materials shipped in bulk, has been growing much more rapidly than the country's overall industrial growth rate. At the same time, water transport of these hazardous products has increased rapidly in certain parts of the country, notably on the western rivers and inland waterways and along the western half of the Gulf Coast. The result has been traffic congestion and a high incidence of marine accidents in certain ports and waterways. Most of these areas, moreover, are within or near densely populated cities where massive release of toxic substances could have drastic effects. Substantial lowering of water levels in these rivers and waterways would further aggravate spill and pollution problems by reducing the volume of water available to dilute and disperse pollutants (lowered stream velocities associated with diminution of flow would also contribute to this problem), and perhaps in other ways.

Factors of great importance with respect to collisions, groundings, and other accidents involving vessels in heavily congested waters are: channel depth and configuration; navigational aids (adequacy and correct placement, especially under conditions of rapid, large physical changes in the water course); the presence of abnormal, or new and unexpected, obstructions; currents and prevailing winds; and others. All but winds are likely to be negatively affected by lowered water levels due to water scarcity. In addition, in low-water situations, water-side

approaches to fires may be more difficult--especially to on-shore or near-shore fires. Under these conditions, greater reliance on helicopter transport of fire-fighting equipment and firefighters might be required.

Technological Possibilities and Ocean-based Effects

Severe inland water scarcity would probably stimulate increased development of various ocean-based activities, including the development of both onshore and off shore desalination facilities, as well as off shore industrial and mining projects. Some inland recreational activities might also move to estuarine and near-shore oceanic areas. All of these developments will have a direct bearing on the mission and day-to-day work of the U.S. Coast Guard; in particular, the enforcement, search and rescue, and safety elements of the Coast Guard mission are likelv to be the most affected.

If the transport of icebergs for fresh-water supplies is attempted--and the prospect seems remote since the feasibility of long-distance transport of icebergs, taking many months and in all kinds of sea conditions, is not proven--the Coast Guard could be involved in several ways. It could participate in the towing activity itself, either towing or monitoring and assisting, and, once U. S. waters are reached, in safety activities, traffic control, enforcement, and problems related to the incursion of large volumes of cold fresh water. The Coast Guard might also be involved in various kinds of research and testing relating to this technology.

Our findings with respect to water supply and demand, and related local, state and Federal government involvement, are as follows:

- With respect to surface water, there is in general more than an adequate supply to meet all demands; however, there are local, and even regional, shortages due to distribution inequities and to pollution.

- The situation is similar for groundwater supplies, except in some regions where water is being withdrawn and consumed at a rate that greatly exceeds recharge.

- The transfer of water (ground and surface) from water rich areas to regions of scarcity is logical, but is discouraged due to water rights, environmental issues, economics, and public attitudes. Federal policy discourages such projects.

- Technological innovations to extend water supply, other than land-based desalination processes, are not yet feasible. Large scale weather modifications, ocean-going desalination plants and iceberg transport are some of the technologies to extend water supplies. These, however, are either in experimental stages or are severely limited by the economics of conversion. None of these technologies are likely to be in large-scale use by the year 2000.

- Technological innovations to decrease demand and consumption exist, but these are limited by economic considerations, by pollution control legislation, and by present federal policy (as well as limitations on funds from federal agencies responsible for policy implementation). For example, water withdrawals for steam-electric generation could be reduced by 25 to 30 percent by means of dry cooling towers that use no water, but do require more energy to operate and are expensive. Irrigation is another prime candidate for water conservation but installation costs for water reducing technology are often not justified under current water and agricultural price relationships.

- Thirteen regions of the United States are expected to experience water supply problems over the next twenty years.

- Examination of forecasts of industrial, agricultural, energy, domestic and recreational activities, in these thirteen regions, all reveal growth, with no tradeoffs between growth activities in any one region being demonstrated.

- Competition among growth activities for scarce water resources will occur.

- Regional problems of competition, including state and local community problems, will be solved at the regional, state and local level. Federal policy and pollution control legislation encourages this approval.

- The role of the Federal government and its agencies is to foster and assist local problem resolution.

RECOMMENDATIONS

The U. S. Coast Guard should maintain close liaison with all government units involved in water resource augmentation planning so that as inland-waterway, coastal, and offshore activities designed to increase water supplies and energy production are planned, it can, in concert, plan actions required to fulfill its mission. Paramount will be the allocation of sufficient funding for the U. S. Coast Guard to expand certain of its operational capabilities as needed.

The U. S. Coast Guard should review its generic mission in terms of regional and budget priorities as well as its operational and regulatory missions. Where possible, interaction and involvement with regions (via USCG District Offices) presently involved in planning for present or anticipated water scarcity situations should increase.

CHAPTER 1. INTRODUCTION

This study is concerned with the impact of water scarcity on the mission of the United States Coast Guard. The Coast Guard's interest in the consequences of water scarcity evolves directly from the Coast Guard's mission, which is summarized as follows:

1. To minimize loss of life, personal injury, and property damage on, over, and under the high seas and waters subject to U. S. jurisdiction.
2. To facilitate transportation, with particular emphasis on water borne activity in support of material economic, scientific, defense, and social needs.
3. To maintain an effective and ready armed force, prepared for and immediately responsive to specific tasks in time of war or emergency.
4. To assure the safety and security of vessels and of ports and waterways and their related shoreside facilities.
5. To enforce Federal laws and international agreements on and under waters subject to the jurisdiction of the U. S., and under the high seas where authorized.

6. To maintain or improve the quality of the marine environment.
7. To cooperate with other governmental agencies and entities (Federal, state, and local) to assure efficient utilization of public resources and to carry out activities in the international sphere where appropriate in furthering national policy.

The Coast Guard's interest in water scarcity flows directly from all aspects of its mission, particularly those related to preservation of human life and safety on the seas and waters, transportation, enforcement, environmental quality, and intergovernmental cooperation. One or two examples, using known technology, illustrate that interest.

Icebergs are a potential source of fresh potable water. They occur naturally but would require movement to a point of utilization. The natural movement of icebergs has long been recognized as a hazard of the high seas, with the Coast Guard providing surveillance and protection to shipping. The planned and controlled transport of icebergs by man would also substantially involve the Coast Guard because much of the movement would be through international waters and because of the impact of the introduction of such large masses of fresh water and cold temperatures into more temperate estuaries and local waterways. Safety of life and shipping would be an important factor throughout such operations.

A second example is desalinization. Desalinization plants would be located primarily in estuarine or coastal areas, with storage facilities and distribution complexes located nearby. The Coast Guard immediately would have important responsibilities related to environmental quality, safety, enforcement, intergovernmental cooperation, and perhaps in regard to other aspects of its mission. Other examples, equally as pertinent, can be given for inland areas, such as in Coast Guard Area 2, which encompasses in whole or in part at least 18 States in central continental U. S.

Thus, the Coast Guard has both direct and ancillary responsibilities that are affected by problems of national, regional, and local water scarcity.

CHAPTER 2 THE GROWING PROBLEM OF WATER SCARCITY

Our awareness of the finiteness of many of our resources has been growing significantly over the past decade. National dependence on foreign sources of petroleum and natural gas, as well as many minerals, has become well known. National programs to further increase this awareness and to encourage conservation have resulted. Not all resources are scarce, however. For example, in the United States there is no scarcity of agricultural products. Indeed, the export of agricultural products has mitigated, to an extent, the economic effects of importing energy and mineral resources. Energy, minerals, and agriculture are linked through their dependence on the common resource, water. Large amounts of water are required for the extraction and processing of minerals as well as for agricultural and energy production. Water is a basic and a finite resource.

WATER AS A SCARCE RESOURCE

The United States as a whole has an abundant water supply. On the average, approximately 42,000 billion gallons per day of water pass over the continental United States in the form of water vapor. Of this, approximately 10.5 percent, or about 4,400 billion gallons per day, precipitates as rainfall, snow, sleet, or hail. Of this total amount, only about 1,400 billion gallons per day, or 9 inches of precipitation, accumulate in

ground or surface storage, flow to the oceans or across national boundaries, or are consumptively used by domestic, agricultural, and industrial activities. The remaining 2,800 billion gallons are returned to the atmosphere through evapotranspiration.

Thus, an average of 1,400 billion gallons of water per day are available for man's use year after year in the U.S. But there have always been local and regional shortages. Population pressures and a variety of consumptive uses of water have combined such that in several regions of the U.S., water is consumed in an amount that exceeds the renewable supply.

National Awareness of the Problem

Periods of water shortage have occurred locally, with varying degrees of severity, for centuries. The last decade has seen the entire southwestern area of the United States affected. Awareness of water pollution problems and effects has increased significantly since enactment of pertinent legislation in the early 1970's. This, coupled with the direct impact of periods of drought, has contributed to the enlarged public understanding of our dependence on an adequate supply of potable water.

POPULATION PRESSURES

Water scarcity can occur because of changes in water supply, because of increases in demand, or both. Changes in supply are due to meteorological phenomena, related to such factors as the movement of moisture from west to east across

the United States, the influences of mountain chains, and the location of major water bodies.

The Pacific northwest is very water rich. The area east of the Mississippi River is also relatively water rich, particularly along the Gulf Coast and along the shores of the Atlantic Ocean. Water-short regions generally include the areas east of the Pacific Coast ranges and east of the Rocky Mountains. The Southwestern states have long been known to be water short.

Population pressures on water supply include requirements for personal use (drinking, cooking, cleaning and washing, etc., and for various outdoor uses). This demand represents but six percent of all water withdrawals (from supply) per year. Population pressures also induce demands in other economic sectors. Increasing population affects agriculture, industry production, energy production, and recreational uses. An expanding population requires more food, energy, and consumer products. The upward mobility (economic) of a population results in demands for additional recreational facilities. Furthermore, an increasing population, with its ancillary demands, creates more pollution.

POLLUTION PRESSURES

Pollution contaminates supplies of water such that they become unfit for domestic or industrial use. Today pollution is controlled by Federal legislation that protects surface, ground, and ocean waters. The genesis of pollution control is Federal legislation. The Rivers and Harbors Act of 1899 was the

first federal law to restrict discharges into navigable waters. Implementation of its potential, however, did not occur until the 1960's. The Federal Water Pollution Control Act of 1948, together with its amendments in 1965, first attempted to set goals or standards for water quality and then to adjust discharges to achieve those goals.

The Federal Water Pollution Control Act Amendments (FWPCA) of 1972 established a new approach to pollution control. The new approach was to control individual discharges to waterways by specific deadlines. Discharge limitations were considered easier to enforce than the earlier goals of water quality.

The Clean Water Act of 1977 modified the timing of various provisions of the FWPCA, redefined pollutants, extended the municipal grants program and substantially modified regulations pertaining to accidental discharges. This Act, together with the Toxic Substances Control Act of 1976 and the Resource Conservation and Recovery Act of 1976, provided a comprehensive set of laws and regulations to achieve pollution control. Provisions of other federal laws, such as the Safe Drinking Water Act and the Underground Injection Control Act, combine to provide the regulatory framework for the regulation of discharges, or for overall pollution control.

Pollution via toxic and hazardous substances can contaminate domestic water supplies. The use of polluted waters for energy production can result in the spread of bacteria

and fungi through cooling tower emissions. Pollution decreases available water supplies. Progress in controlling the discharge of pollutants into water sources has been substantial. Progress in cleaning up polluted water bodies has been slow; considerable time is required for a water body to recover once the discharge of pollutants is stopped. The progress made to date is expected to continue at an increased pace over the next 20 years as the arsenal of legislative controls is further implemented.

INDUSTRIAL USE PRESSURE

Industry includes manufacturing and mining activities. In 1955, the industry demand for water was approximately 36 billion gallons per day. By 1975, this demand had risen to over 58 billion gallons. More importantly, over the same time period, consumption increased by a factor of two. Industrial expansion also contributed to the doubling of the water required for electricity production. This increase resulted from an expanded population and economy.

Over the next 20 years, demand is expected to decrease as conservation measures associated with pollution control legislation and with the economics of supply are further implemented. Reliance on conservation to include the reuse and recycling of process waters will bring about the expected decrease.

The combination of population, pollution, and industry pressures for available water supplies varies tremendously across the United States. Twenty-eight percent of the U.S. land

area and 13 percent of its population already face water scarcity situations due to a combination of factors unique to the drainage area or river basin within which they are located. As an example of the nature of the problems created by these combined pressures, both now and expected over the next 20 years, regional profiles are presented in the next chapter (Table 3-2). Representative water scarcity incidents are presented below.

REVIEW OF REPRESENTATIVE WATER SCARCITY INCIDENTS

The economically useful water resources of the United States are quite unevenly distributed. The most gross division would be to say that those parts of the United States lying east of the 100th meridian are humid and moist, with plentiful rainfall, and those west of the 100th meridian (with the exception of the Pacific Northwest) are semiarid, with scant rainfall. The distribution of population, economic activity and types of water is also far from uniform.

The semiarid West, with its small natural endowment of water, has, for various reasons, a highly water-consumptive economy, both developed and projected. How it became possible and profitable to undertake such economic activity in an arid environment is a question that can be answered only by a broad treatment of United States economic history, and, in particular, the history of resource development policy. Thus, it is not surprising, at any rate, that the water problems of the West as perceived by many people should be problems of water availability

for these water-intensive activities. To be able to regularly meet the needs of these activities, most of the western water systems are generally called upon to operate at near capacity most of the time.

In the eastern, central, and midwestern regions, due to the growth of population and industry and traditional reliance on water-course disposal of waste (including heat), many streams have been overburdened. This has created severe water quality problems in these regions.

However, common to both the regions, though different in severity, is the problem of infrequent and unpredictable droughts. These droughts are normal climatological phenomena, though man cannot as yet forecast their occurrence with certainty or (once they are upon us) determine how long they will last, or the extent of drought-caused losses. It seems no part of the nation is immune to drought, though droughts of several years duration are rare in the U.S. The East generally has short-term, seasonal droughts; it appears that the Northeast drought of 1962-66 was an event that might be expected an average of only once every 150 years.

During the 1930's, the Great Plains were beset by abnormally low precipitation. In combination with high winds and extreme temperatures--compounded by years of overgrazing and of generally poor farming techniques--great dust storms developed, so that much of the land lay useless for many years. In the

late 1940's and early 1950's, a drought occurred in the Southwest and in places in the southern mid-continent. In some parts of the Southwest, the drought continued for more than 10 years. Even though the drought of the early 1950's was more severe than that of the mid-1930's, the national impact was far less severe. This was because the stronger national economy could more easily absorb the losses and because conservation programs had made many areas less vulnerable to drought. In 1976-77, the nation was again beset by drought--the worst in modern times--which centered in the west-northwest and upper parts of the Midwest. The humid East suffered from local drought as well. However, particularly in California, the drought forced mandatory cutbacks in water use and raised serious questions concerning the future standards for water supply planning, the need for shared use of existing supplies, the long-term desirability of various short-term water conservation measures, and the levels to which the quantities of waste waters should be reclaimed and reused to supplement basic water supplies. Added to these were controversies over water supply, environmental issues, costs, and land use issues that had been occurring since the early 1970's and had delayed any expansion of existing water supply systems ,in many parts of California, in particular. As the drought continued through the winter of 1976-77, many utilities, with no other option, successfully implemented water rationing designed to reduce consumption by 25-35 percent (see Table 2-1). However,

TABLE 2-1:

Summary of Some Past Drought Management Measures*
And Resulting Decreases In Consumption

Location	Year	Restriction Imposed	Resulting Decrease
New York City	1968	Ban outside use; appeals	10-22%
Pawtucket, RI	1967	Ban on outside use; appeals	16-18%
17 Eastern Utilities	1972	Voluntary and compulsory bans on outside use; appeals	18-50%
Washington Suburban Sanitary Commission, Washington, DC	1977	Ban on outside use; appeals to specific acts	40%
Marin Co., CA	1977	Ban on outside use; rationing, with fines	25% 63%
Oakland, CA	1978	Rationing, with fines	38%
Denver, CO	1978	Limiting outside use to 3 hrs. every 3rd day	21%
Los Angeles, CA	1978	Appeals and limited industry cutbacks, with some mandatory controls	10-20%
California	1978	Voluntary rationing	Up to 20% Up to 50%
**Northern Virginia	1981	Voluntary	Up to 20%

*Adapted from "The Role of Conservation in Water Supply Planning," p. M9, Contract Report No. 78-2, Institute of Water Resources, U.S. Army Corps of Engineers, April 1979.

**The Washington Post, p. C-8, January 23, 1981.

such non-legislated rationing can only be achieved through voluntary commitment of the consumer, and to get that commitment, the utility must communicate the shortage problem and the required rationing solution to the consumer. Rationing was also carried out in the exceptionally dry summers of 1964-65 in the Northeast.

More recently, in January 1981, Governors of four States that are served by the Delaware River Basin--New York, New Jersey, Delaware, and Pennsylvania--when faced with the prospect of a severe drought, declared a water emergency affecting the 22 million people inhabiting the area. New York City, in particular, was required to cut 40 million gallons from the 560 million gallons it draws each day from the reservoir system at the headwaters of the Delaware River. Concern was expressed not only about the shortage of water but also that the river would not flow fast enough to cleanse itself of pollutants.

Among the other options, inter-basin diversions, desalting, and the development of large-scale integrated urban supply systems have all been recommended, particularly for urban drought protection in areas that are subject to severe but infrequent droughts. It is imperative, therefore, that in long-range water management and planning, natural phenomena such as droughts must be considered along with the political, economic, and environmental influences.

CHAPTER 3. DATA SOURCES AND BASELINE INFORMATION

1975 WATER DEMANDS AND PATTERNS

Water demand may be expressed in terms of water withdrawn and water consumed. Water withdrawn is the amount taken from source supplies (surface and ground). Water consumption is that portion of the withdrawn water that is not returned to the source. The difference between withdrawal and consumption is that amount returned to a source. Prior to return, this water may be treated to remove harmful pollutants.

In 1975, the average daily amount of fresh water withdrawn in the United States was 338.5 billion gallons (from both surface and ground sources). The quantity consumed averaged 106.6 billion gallons per day. This means that approximately one third of the total water withdrawn was not replaced for subsequent use. Water is also withdrawn from saline sources, primarily for conversion to fresh water by desalination processes. The direct use of saline water by industry or agriculture is not yet practiced in the United States. In 1975, saline water withdrawals averaged 59.7 billion gallons per day.

Thus, in 1975, water withdrawals (fresh and saline combined) averaged 398.2 billion gallons per day, or 145,343 billion gallons during the year; total water consumption for the year was 38,909 billion gallons. Withdrawals were to satisfy demands exerted by the various economic sectors of the economy: domestic uses, manufacturing, agriculture,

steam-electric production, mineral production, recreation, and others. Each sector is also responsible for consumption of a portion of the water withdrawals. Data for 1975 for each economic sector are summarized in Table 3-1.

Patterns of use by sector of the economy since 1955 show stability or gradual increases in the total quantity of water withdrawn. The largest increase in water withdrawal is for irrigated agriculture. Domestic and commercial uses, as well as mining and manufacturing, exhibit stable withdrawal patterns. Patterns of consumption over the same time period, however, show a drastic increase in water consumed by irrigated agriculture (approximately 100%). Increases in mining and manufacturing are reasonably consistent with increased withdrawals.

Regional patterns of water withdrawal, by sector of the economy, are shown in Table 3-2. Regions are as defined by the Water Resources Council and include all of the United States and the U.S. Caribbean Islands, as shown in Figure 3-1. These data reflect the relative population densities in each region as well as the 1975 mix of water intensive industries.

In 1975, the demand for water was met by withdrawals of 274 billion gallons per day (BGD) from surface waters and 61 billion gallons per day from groundwater. Additional quantities of 59.8 and 21 BGD were derived from saline and groundwater mining, respectively. Surface water supply in the nation in 1975 was estimated at 2,159 BGD and groundwater at 82.4 BGD, for a

TABLE 3-1: Summary of 1975 Water Withdrawal and Consumption by Sector of the U.S. Economy

Sector	1975 Withdrawal (BGD)	1975 Consumption (BGD)	Consumption as Percentage of Withdrawal
Domestic	23.3	6.2	27
Municipal	21.2	4.9	--
Rural	2.1	1.3	--
Commercial	5.5	1.1	20
Manufacturing	51.2	6.0	12
Agriculture	160.6	88.3	55
Irrigation	158.7	86.4	--
Livestock	1.9	1.9	--
Steam Electric	88.9	1.4	2
Minerals	7.2	2.3	32
Recreation & other	1.8	1.3	72
Total Fresh Water	338.5	106.6	31
Total Saline Waters	59.7	--	--
Total	398.2	106.6	

TABLE 3-2: Summary of 1975 Water Withdrawals by Region * and by Sector of the U.S. Economy (Millions of Gallons Per Day)

Region	Domestic & Commercial	Manufac-turing	Agriculture	Steam Electric	Mining	Recreation
1. New England	1483	2169	35	1263	90	70
2. Mid-Atlantic	4604	5416	265	7463	495	218
3. South Atlantic-Gulf	2841	4105	3464	12768	1178	161
4. Great Lakes	4277	13218	145	24362	696	220
5. Ohio Basin	2337	10879	47	21022	493	142
6. Tennessee Basin	353	2094	14	4799	110	23
7. Upper Mississippi Basin	1965	2029	192	7644	333	97
8. Lower Mississippi Basin	805	4159	4580	4175	799	41
9. Souris-Red-Rainy Basin	68	102	46	82	8	5
10. Missouri Basin	1246	668	31636	3540	269	62
11. Arkansas-White-Red Basin	945	714	9980	498	448	45
12. Texas Gulf	1490	1931	11538	724	1044	63
13. Rio Grande Basin	327	19	5684	34	190	11
14. Upper Colorado Basin	80	4	6400	101	132	2
15. Lower Colorado Basin	498	87	7989	68	184	15
16. Great Basin	378	112	6969	33	145	8
17. Pacific Northwest	1078	2324	33181	260	118	43
18. California	3388	796	34611	42	297	135
19. Alaska	91	133	4	25	30	2
20. Hawaii	177	251	1447	0	1	8
21. Caribbean	355	N/A	516	0	31	N/A
Total	28786	51210	158743	88904	7055	1381

* See Figure 3-1 for region outlines.

FIGURE 3-1

Water-Use Regions* as Delineated by the Water Resources Council

* See Table 3-2 for names of regions

total of 2241.4 BGD, excluding the oceans. Comparing the 1975 withdrawals of 398.2 with the supply of 2241.4 shows adequate supply. However, there are localized problems of inadequate surface and groundwater supplies (west and southwest U.S.), surface and groundwater pollution, flooding, erosion and sedimentation. The result is that there is an inequitable distribution of supply with respect to demand in approximately two thirds of the nation. These problem regions are defined and examined in the next section.

PROJECTED YEAR 2000 DEMANDS AND PATTERNS

Demands

Various methodologies were examined for use in projecting water demand. Projections, by sector or user, were available from the Water Resources Council. Available data were obtained to construct an independent set of projections that could be compared with existing forecasts.

Historical data on the withdrawal of surface water and groundwater, and of fresh and saline water, for use in domestic and commercial applications, manufacturing, agriculture, electricity generation, and mineral processing, were obtained and examined. Data prior to 1950 were not used in forecasting because:

1. The data were incomplete.
2. They reflect policies not currently in force.
3. Increased use of technology has occurred in industrial processes.

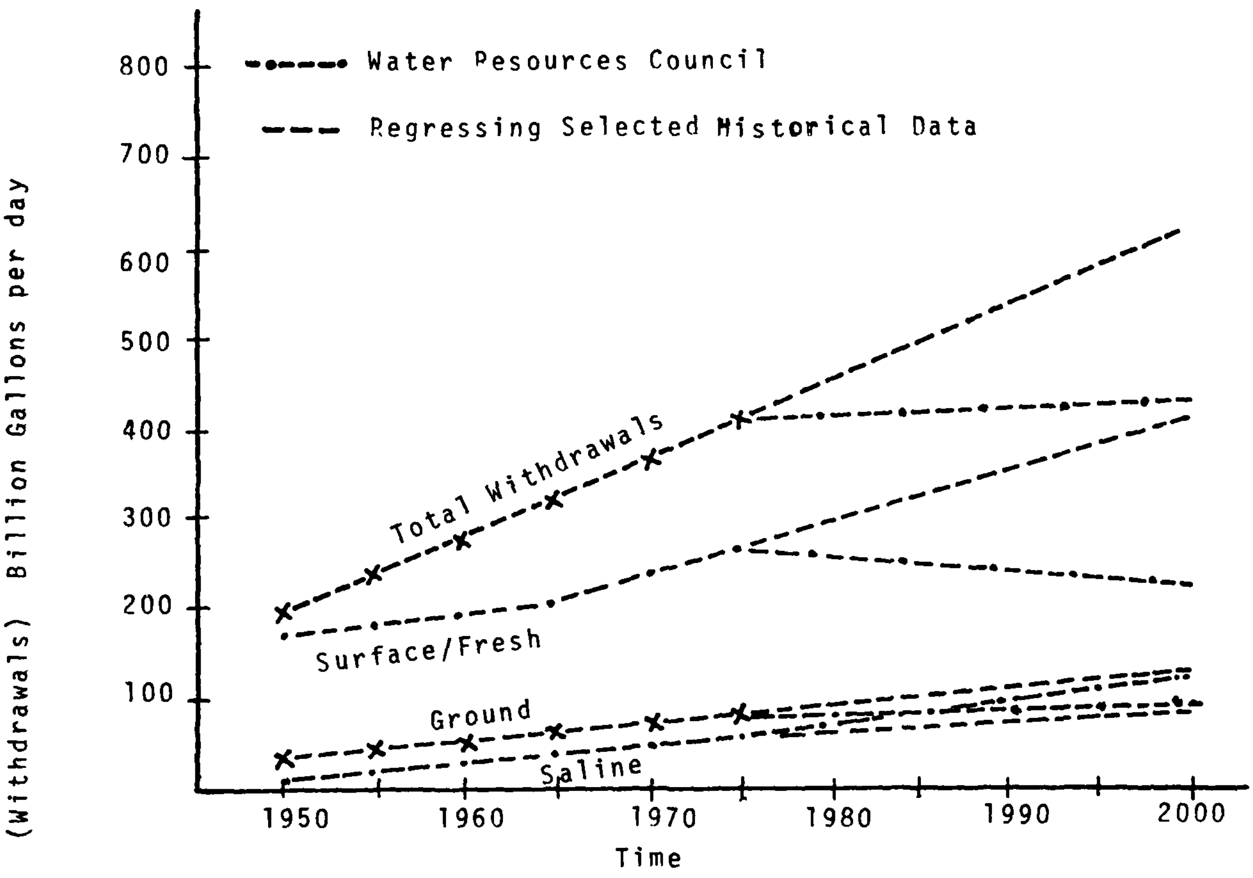
4. Major pollution control requirements have been improved (since 1960), encouraging reuse, recycling, and conservation.

Available data are plotted in Figure 3-2, along with projections of those data. Two forecasts are shown. The dashed line represents a linear regression based on historical data. These forecasts are dependent on assumptions that past data are representative and that past withdrawals and practices will continue throughout the forecast period. Linear regression analysis, compared to other forecasting techniques such as moving averages and exponential smoothing, econometric methods and subjective methods, was chosen as it was considered quite appropriate for the analysis in view of the fact that the relationships could be well represented linearly. Nonlinear effects are not very significant in such cases. It is interesting to note that the projection of total withdrawal indicates a year 2000 value approximately twice (1200 BGD) that shown in Figure 3-2.

The lower projection is as provided by the Water Resources Council (WRC) in the 1975 Assessment. The forecast assumes substantial reuse and recycling in manufacturing and other industries, and in steam-electric generation. The forecast also assumes extensive conservation in agriculture and in domestic and commercial water use. This forecast is considered to represent the results of implementation of present federal policy over the next 20 years.

FIGURE 3-2

Historical and Forecasted Water-Withdrawal Data



Two factors that would affect projections were considered: recycling of treated wastewater effluent and consumption. Historical data from 1955 for the use of treated wastewater as a water source either for industrial or agricultural purposes, and data for ground water recharge were reviewed. Available data for recycling of treated wastewater are shown in Figure 3-3.

FIGURE 3-3

Utilization of Reclaimed Waste
Water as a Water Supply

The sharp increase in use between 1960 and 1965 is representative of the interest in land treatment of municipal sewage. The historic data are insufficient to permit accurate forecasting. However, based on a review of literature, it is probable that significant utilization of this resource will not occur. The direct use of reclaimed sewage for domestic/commercial use is not probable. Applications involving spray irrigation and aquifer recharge could occur, particularly in water-scarce regions ,during the forecast period.

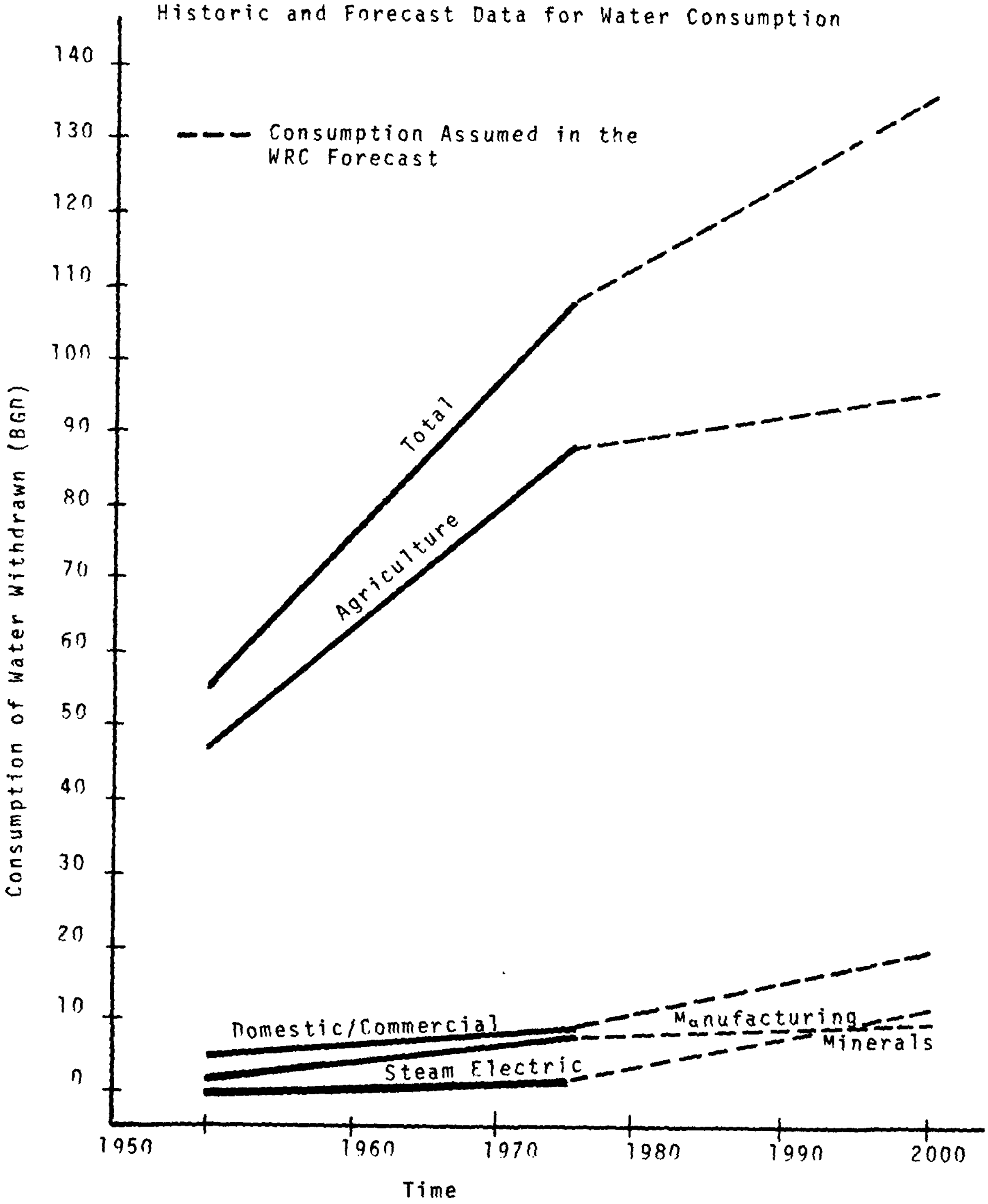
Consumption of water is perhaps more critical than water withdrawal since consumption means that downstream supply may be inadequate to meet subsequent demand. Policy emphasis on reuse and recycling could increase consumption of withdrawn supply. Further, it would concentrate pollutants such that more costly forms of wastewater treatment would be required. Historic and forecast values of consumption, in terms of sector use, are presented in Figure 3-4. The values presented are consistent with the WRC forecasts. The ambitious estimates for agriculture may not be realized. Higher consumption would increase the quantity of water withdrawn and, therefore, support the higher withdrawal projections shown in Figure 3-2.

Patterns

The Water Resources Council has divided the contiguous United States into 18 river basins plus one each for Alaska, Hawaii, and the Carribbean, as defined in Table 3-2 and outlined

FIGURE 3-4

Historic and Forecast Data for Water Consumption



in Figure 3-1. These basins have been further disaggregated into a total of 106 subbasins, also as shown in Figure 3-1.

A task force was established by Executive Order to investigate water scarcity in 1977-1978. That study found that severe water shortages existed in 21 of the 106 subregions as defined by the WRC. Further, potentially severe shortage could be anticipated in an additional 18 subregions by the year 2000. The 21 areas of the U.S. already affected by water shortages comprise 28 percent of the U.S. land mass and include 18 percent of the population. Over 90 percent of the water consumed in these areas is used by agriculture, mainly for irrigation. Further, one-third of this consumption is drawn from a fixed stock of groundwater. This fixed stock can neither be renewed nor replaced, except at very high cost.

The accelerating depletion of groundwater coupled with the fact that groundwater can only be replenished by surface supplies indicates that surface water must play a key role in meeting the future needs of water-deficient areas.

Surface-water supplies can be used for industrial and energy production as well as for instream uses such as navigation and recreational activities. It is also used, along with groundwater, for domestic and commercial purposes. Urban water consumption represents less than six percent of the national total. However, this use increased by 13.5 percent between 1970 and 1975, while the population served by urban supplies

increased only six percent. The result has been seasonal or short-term water shortages in certain urban areas outside the western states, such as Boston, Washington, D.C.,and Atlanta.

Available data were examined in order to isolate those regions of the United States that might experience a water problem between 1975 and 2000. These data are presented in Table 3-3. The table shows that all of the United States and its territories in the Caribbean are facing water problems of one form or another. Water supply problems are expected in portions of 11 major basins during the forecast period; water pollution problems are expected in some 21 basins.

The projections shown in Figure 3-2 were extended to each major sector of water use for each of the 11 regions of the country expected to be affected by water scarcity over the next 20 years. The results are shown in Table 3-4 as 1975 baseline data and as two values for the year 2000. The 2000 "high" values are disaggregated according to the regression lines of Figure 3-2. The 2000 "low" values are disaggregations of the WRC projections.

In terms of total quantity or supply of fresh water from surface and groundwater sources, there will be no scarcity in terms of the projected demand. The data of Table 3-4 show, however, that in some regions of the United States local supplies are already inadequate. Projections of demand for these regions show that, in spite of present short supplies, water demand is

TABLE 3-3. Regions of the U.S. with Water Supply or Water Pollution Problems, 1975 to 2000 A.D.

Regions	Supply Problems		Point	Non-Point	Pollution Problems		Drinking
	Stream Flow	Ground Water			Eutrophication	Ground Water	
New England			x	x	x	x	x
Mid-Atlantic			x	x	x		x
South-Atlantic Gulf		x	x		x	x	x
Great Lakes			x	x	x	x	x
Ohio			x	x	x	x	x
Tennessee			x		x		x
Upper Mississippi		x	x	x	x	x	x
Lower Mississippi		x	x	x	x		x
Souris-Red-Rainy			x		x	x	x
Missouri	x	x	x	x	x	x	x
Arkansas-White-Red	x	x	x		x	x	x
Texas-Gulf		x	x		x	x	x
Rio Grande	x	x		x	x	x	x
Upper Colorado				x	x	x	x
Lower Colorado	x	x	x	x	x	x	x
Great Basin	x	x	x	x			x
Pacific N.W.	x		x		x		
California	x	x	x	x	x	x	x
Alaska			x		x	x	x
Hawaii		x	x	x	x	x	
Caribbean	x	x	x			x	x

TABLE 3-4. Forecasts of Water Withdrawals by Use Category for those Basins Expected to Be Affected by Water Scarcity (Millions of Gallons per Day)

Basin Experiencing Water Supply Problem	Domestic/Commercial			Manufacturing			Irrigation		
	1975	2000 high	2000 low	1975	2000 high	2000 low	1975	2000 high	2000 low
South Atlantic Gulf	2841	6798	4254	4103	4960	3318	3464	6840	4509
Upper Mississippi	1965	3708	2411	2030	1120	728	192	684	387
Lower Mississippi	805	1545	960	4163	2080	1365	4580	6840	4444
Missouri	1246	2472	1497	669	480	292	31636	57000	36236
Arkansas-White-Red	945	1854	1132	713	640	480	9980	15960	9776
Texas-Gulf	1490	3090	1921	1932	3680	2444	11538	11400	7427
Rio Grande	327	618	380	19	64	32	5684	6840	4873
Lower Colorado	498	1236	772	89	160	138	7989	9120	6343
Great Basin	378	927	530	112	144	98	6969	9120	5825
Pacific Northwest	1078	1854	1264	2324	1600	1132	33181	47880	29961
California	3388	6798	4360	796	1120	828	34611	56316	34764

TABLE 3-4. (cont'd) Forecasts of Water Withdrawals by Use Category for Those Basins to Be Affected by Water Scarcity (Millions of Gallons Per Day)

Basin Experiencing Water Supply Problem	Steam Electric			Minerals Industry			Water Based Recreation Activity 1975-2000 (% Increase)
	1975	2000 High	2000 Low	1975	2000 High	2000 Low	
South Atlantic Gulf	12768	21792	13952	1178	3640	2077	32
Upper Mississippi	7644	5448	3537	333	910	533	23
Lower Mississippi	4175	26559	16687	799	2210	1318	18
Missouri	3540	7491	4938	269	780	424	20
Arkansas-White-Red	498	1362	1012	448	1040	571	20
Texas-Gulf	724	2724	1713	1044	2080	1245	30
Rio Grande	34	14	10	190	390	255	18
Lower Colorado	68	272	154	184	520	311	39
Great Basin	33	136	82	145	520	273	34
Pacific Northwest	260	68[illegible]	580	118	260	167	20
California	42	1621	367	297	650	375	29

expected to increase in all use categories. Technological advances (discussed in Chapter 5) will be necessary if this conflict between increased demand and dwindling supply is to be resolved.

The South Atlantic-Gulf Region

The South Atlantic-Gulf Region encompasses a total area of about 271,384 square miles. The region contains 24 major river basins and many minor coastal river systems. It has ample surface and groundwater to provide for an expanding economy. Coastal plain areas generally contain an abundance of good quality groundwater that can be developed for human use. However, these water resources are not always well-located within a region with respect to needs, and local water shortages already exist in highly developed upstream areas. Steam-electric plants currently make the largest water withdrawals; there also are large water demands by the paper and pulp industry.

Major water problems occur as a result of population and industrial growth, and related growth of water demand, in areas where water is limited. Stream headwater areas are particularly affected. In other areas, overpumping of groundwater has led to salt water intrusion, another threat to usable water supply. In addition to water quantity limitations, there are problems of excessive pollutants reaching the streams and coastal waters, and, in some areas, threatening groundwater resources. Protection of the beach areas and associated waters from erosion and water quality degradation is a major concern.

Conflicts over the dredging and filling of wetlands, among other water and related land use issues, are a major concern within the region. Numerous management problems occur along interstate streams regarding interbasin and interstate transfers of water, and the region contains many environmentally sensitive areas.

The Southern Coastal Plain region is currently experiencing rapid population increases due to immigration from the northeast as well as a continued influx of refugees. Some of the common problems in the region include:

- Population concentration causes urban water supply problems
- Expanding economies require more water
- High use of water for irrigation
- Salt water intrusion in near-shore and estuarine areas caused by ground water overdraft
- Lack of water conservation

The number of steam-electric power plants, currently making the largest water withdrawals in this region, is likely to increase by five times or more by the year 2000, resulting in further, greatly increased, water withdrawals. It is projected that most of the new power facilities, for reasons of efficiency and economy, are likely to be 1000 megawatts or more in size, raising the possibility that some local waters will not be able to support the increased consumptive losses or to assimilate waste heat without costly and auxiliary cooling systems.

Moreover, the peak electrical demand in the South Atlantic-Gulf region, due to geographical conditions, occurs during the summer months. Summer is generally the period of lower river flows, higher water temperatures, and decreased waste assimilative capacity--a combination of factors that exacerbate water shortage problems.

The Upper Mississippi Region

The Upper Mississippi Region includes the drainage area of the Mississippi River above its confluence with the Ohio River. It encompasses about 180,731 square miles. Many rivers flow through the region in a general north-south direction, with the Mississippi River bisecting the area. Tributaries of the Mississippi drain most of Minnesota, Wisconsin, Illinois, and Iowa; a significant portion of Missouri; and small areas in Indiana, Michigan, and South Dakota. The Upper Mississippi River is a key element in the nation's inland waterway system. Large amounts of ground water are stored within much of the region. The regional gross water supply situation is very good, and land and water resources are ample to provide for an expanding economy with a quality environment.

Water is withdrawn from the streams and ground for many uses; the largest amount is used as cooling water for steam electric plants. Most water problems in this region are associated with water quality, erosion and sedimentation, flooding, land use conflicts, local water supply, instream flow inadequacies,

drainage, navigation, and dredging. Water quality problems and erosion and sedimentation tend to be more severe in the downstream areas.

Water quality is often a major concern in metropolitan areas, while serious water supply shortages occur in some rural places. During drought periods, locally high withdrawal and consumptive-use demands create supply and instream flow problems.

The largest use of water currently withdrawn is for steam electric although irrigation, manufacturing, urban water and minerals industry use a portion. Steam electric generation is expected to increase five fold the 1975 level, although water withdrawals for electrical power generation would not increase proportionately. Mineral production and mining have relatively minor water needs compared to those of large users such as agriculture. Mineral production includes the extraction and primary processing of three types of minerals: metals, nonmetals, and fuels. The mineral industry accounted for only 2.1 percent of the nation's fresh water withdrawals in 1975; however, with increasing demand for minerals, these water withdrawals are expected to increase by about 61 percent by the year 2000, to approximately 3.7 percent of the nation's fresh water withdrawals. Consumption is projected to increase by 74 percent by 2000.

The Upper Mississippi region is expected to increase its overall water withdrawals by about 150-200 percent by the year 2000. Current trends in mineral mining in the region are

toward large-scale mineral operations. Processing lower grade ores requires higher capital outlays and longer-term market commitments and generally requires more water per unit of production. This trend will contribute significantly to the tremendous increase in water usage by mineral industry by the year 2000.

<u>The Lower Mississippi Region</u>

The total area of the Lower Mississippi Region is about 105,177 square miles and the region includes portions of Missouri, Tennessee, Kentucky, Arkansas, Mississippi, and Louisiana. The Mississippi River and the Gulf Intracoastal Waterway are nationally important navigation systems.

In general, water supplies are adequate, and most water supply problems are related more to resource distribution than to availability. The region has vast groundwater reserves and benefits from the tremendous inflow from the Upper Mississippi and its tributaries. Localized shortages occur because of lack of access to drainage arteries or because of poor or insufficient groundwater sources. The largest portion of water withdrawals is used for irrigation. The major needs and problems are concerned with water supplies for municipal, industrial, thermo-electric power generation, energy production, and irrigation uses and with developments for navigation, flood control, land treatment and management, fish and wildlife habitat, and water-oriented outdoor recreation. The maintenance and improvement of the existing navigation system in the Lower Mississippi region is important on both regional and national levels.

Flood control on the Mississippi River and its tributaries is a most severe and urgent problem, as approximately half of the Lower Mississippi region is subject to flooding. Most of the flood-prone lands are used for crop production and pasture. Meeting the increased future need for food will require continued and accelerated planning for flood control and other resource development measures to ameliorate the major agricultural losses attributable to flooding.

The steam-electric industry is forecast to increase total water withdrawals in the region. The region is also expected to become the largest water user in the nation for oil and gas recovery and processing, especially in the rapidly expanding use of secondary recovery methods, which involve injection of water to flood older wells. These water withdrawals are expected to increase from 644 million gallons in 1975 to about 1065 million gallons by the year 2000.

The Missouri Region

The Missouri Region contains one-sixth of the land area of the 48 contiguous states, about 511,309 square miles. There are few natural lakes; most of the region's available water areas is in and around manmade reservoirs. Six large reservoirs on the Missouri River main stream generate most of the regions' hydropower, maintain adequate flows for an 8-month navigation season and provide for water-quality control and water supply needs. They also permit diversion of water northeastward and eastward for

irrigation and for municipal and industrial needs. Other manmade tributary reservoirs provide additional storage capacity, with most of the water surface used for recreation; they also provide for fish and wildlife propagation and preservation.

Water shortages occur at many locations throughout the region during periods of low streamflow. Seven states in the region are considered to have water-short areas. A great portion of the water consumed in the region is used for irrigation. This situation will probably continue as the number of acres of land under irrigation has been increasing steadily and is expected to continue to grow.

The Northern Great Plains of the Missouri Region contain large reserves of low-sulphur coal, which will probably be used to meet a significant portion of the country's future energy needs. Withdrawals for mining of this fuel will increase from 144 MGD in 1975 to 236 MGD in 2000.

There are numerous water and related land use problems throughout the region. Because Indian and Federal reserve water rights have not been quantified, it is difficult, and sometimes impossible, to plan for using and managing the available water supplies in large areas of the region. The projected estimates of future water use indicate that, during extended drought periods, sufficient water to maintain navigation flows may not be available. The western streams are particularly susceptible to

fluctuations since they are fed only by spring snowmelt and run off from erratic rainfall. At times, the only streamflow results from reservoir releases or irrigation return flows. Sheet, gully, and stream back erosion result in the loss of valuable soils and usable lands at many locations, and make silt the worst pollutant throughout the region. Some communities suffer periodic flooding, and many suffer periodic water shortages. Non-point source pollution will continue to impair water quality.

The Arkansas-White-Red Region

The Arkansas-White-Red Region has an area of about 244,083 square miles. All three rivers discharge into the Mississippi River and together they drain all of Oklahoma and parts of Colorado, Kansas, Missouri, Arkansas, New Mexico, Texas, and Louisiana.

The overall water supply outlook is tenuous since much water resource development will be needed to keep pace with growing water demand while preserving desired environmental conditions. The quantity of water available in the western and central areas is inadequate for many requirements. Irrigation accounts for the largest portion of water withdrawals and consumptive use.

Difficult water supply problems are experienced in the high plains and central areas, and these will require cities and industries to change their patterns of water use to meet pollution discharge restrictions and to satisfy supply needs

economically. In addition to water quantity limitations, there are concerns about water quality, erosion and sedimentation, flooding, and Indian water rights. The large irrigation water requirement often accentuates these problems by creating low streamflows and groundwater depletions.

To permit better utilization of water, various compacts between states may be required. The continuous depletion of groundwater supplies due to inadequate recharge and the constantly increasing irrigation needs could be a significant water supply problem in the area, particularly with the projected increases in electric power generation and in the mineral industry by the year 2000. The e will be intense and increasing competition for the region's water supply. Water will be diverted from irrigation, causing changes in the agriculture-based economy of the region. Growth and development of energy-related industries would create new jobs and further impact on the economic base of the region. With agriculture and energy competing for water supplies, new industries may not be able to develop, resulting in a relative decrease in industrial and economic activity. This could affect the standard of living of the region.

<u>The Texas-Gulf Region</u>

The Texas-Gulf Region comprises about 177,754 square miles. Virtually all of the region lies within Texas, although small portions of Louisiana and New Mexico are included. Much

fluctuations since they are fed only by spring snowmelt and run off from erratic rainfall. At times, the only streamflow results from reservoir releases or irrigation return flows. Sheet, gully, and stream back erosion result in the loss of valuable soils and usable lands at many locations, and make silt the worst pollutant throughout the region. Some communities suffer periodic flooding, and many suffer periodic water shortages. Non-point source pollution will continue to impair water quality.

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of the region consists of the drainage areas of the Sabine, Neches, Trinity, San Jacinto, Brazos, Colorado, Lavaca, Guadalupe, San Antonio, and Nueces Rivers and associated coastal basins. These rivers drain generally northwest-to-southeast and into the Gulf of Mexico. The ports in the Texas-Gulf region are among the busiest in the nation.

Historically, groundwater has met an appreciable percentage of total water supply requirements. Because pumpage exceeds natural recharge in most aquifers, however, the region will become increasingly dependent on surface water supplies. In many areas, especially in the western portion of the region, water supply will become critical. Irrigated agriculture uses the largest amount of water. In much of the Texas-Gulf region there is little excess storage capacity in surface water reservoirs to meet water demands during drought. Coupled with declining groundwater resources, this could result in serious supply shortages.

In addition to supply limitations, there are problems of water quality, flooding, drainage, erosion and sedimentation, inadequate water-oriented recreation opportunities, and land subsidence and fault activation. Estuarine management would help assure sufficient fresh water inflows at appropriate geographic locations.

Major water problems in this region can be summarized as follows:

- Groundwater overdrafts result in decreased contributions from aquifers
- Land subsidence and saline-water encroachment as a result of pumping from aquifers
- Curtailment of municipal, industrial, and agricultural growth as the consequence of water shortages
- Decline of agricultural industries due to depletion of groundwater supplies
- Water quality problems resulting from natural salt sources in some river and estuarine systems.

Water scarcity currently exists in the western part of the region and is likely to become critical in the near future. As a result of continued groundwater mining, supplies stand at a very low level in most of the region while at other places they have totally disappeared. Irrigation is currently the major user of water, though manufacturing and energy producing facilities are projected to exceed this usage. The region also has the highest concentration of refineries and the largest gross water usage for refining. However, by substituting saline water for fresh water and by recycling, the refining industry has been able to satisy its water requirements. The situation is likely to change in the near future as the use of saline water is projected to be phased out by year 2000 and replaced with recirculating fresh water systems.

The region is also projected to significantly increase water consumption in secondary recovery operations of oil. The result is that fresh water withdrawals for petroleum refining, counter to the national trend, are projected to increase considerably. Domestic and commercial water use are also expected

to increase. The potential competition from other sectors due to the potential increase in their growth, as well as the projected increase in population in the region, could cause intense competition for water in the Texas-Gulf region. This competition is likely to divert irrigation water to other regional uses in the absence of any alternate water sources.

The Rio Grande Region

The Rio Grande region, in the southwest corner of the United States, has a total area of about 137,175 square miles. The Rio Grande River flows south-southeastward to the Gulf of Mexico; its waters are regulated by various treaties and compacts between the United States and Mexico and among Colorado, New Mexico, and Texas. Closed basins are an important factor in the region's hydrology. Groundwater is an important component of the water supply, which will be under added stress due to increasing future population. There is no surplus water for new or expanding current uses since the existing supply is completely appropriated by current demands. Irrigation is the major water consumer.

Shortages exist in meeting current needs, making conservation a necessity. Groundwater depletions are anticipated, along with salinity problems caused by reuse of water in the basin. Dissolved and suspended solids are major pollutants, degrading water quality. Other problems involve erosion and sedimentation, flooding, unsatisfactory domestic water supplies

(under the 1974 Safe Drinking Water Act), and the need for more water-based recreation opportunities.

The Lower Colorado Region

The Lower Colorado Region encompasses an area of about 154,848 square miles. It includes several closed basins in Arizona, western New Mexico, southern Nevada, southwestern Utah, and parts of Arizona and New Mexico that drain into Mexico. Except for a portion of southern California, the region is hydrologically defined by the drainage area of the Colorado River below Lee Ferry, Arizona. The Lower Colorado region receives an annual apportionment of Colorado River water, as established by various treaties and compacts.

Though the Colorado River System is one of the more water-deficient river systems in the nation, over half the population of the west is dependent on its meager and poorly distributed water supply. Current water uses are exceeding available renewable supplies. The deficiency is now being met by overdraft of the groundwater supply in central Arizona and southern Nevada. Water withdrawals are used mainly for irrigation; almost half of the irrigated acres in the region are dependent entirely on the dwindling groundwater supplies.

The average annual supply of the Colorado River soon will be inadequate to meet treaty and compact requirements. Surface and groundwater supplies are insufficient to meet present

uses, and aquifers are being overdrawn. As groundwater levels drop, problems associated with increased pumping costs, land subsidence, and earth fissures become more prevalent. A major water quality concern stems from the high levels of dissolved mineral salts. The Lower Colorado also experiences problems of flooding and of erosion and sedimentation.

<u>The Great Basin Region</u>

The Great Basin Region encompasses approximately 139,389 square miles in Utah, Nevada, and Idaho. Most of the streamflow in the region originates in the high mountains at its eastern and western edges. The region is part of a hydrologically closed basin, and all of the rivers and streams eventually end in terminal lakes or sinks where evaporation creates high salinities.

The available water supply in the region is not sufficient to meet needs in many areas. Streamflows vary seasonally and diminish drastically in later summer; therefore, surface water resources are poorly distributed with respect to time and location. Groundwater supports most developments located away from the base of the mountains, but recharge rates are low and storage depletions occur in the central parts of the region. Irrigation is the largest use of withdrawals from surface and groundwater sources.

The scarcity of water in the region generates competition for its use and for land that is well-located with respect

to water. In several areas, lack of water is impeding further economic development, and urbanization of agricultural lands is causing conflicts. The region's ample land resources cannot be used to the fullest extent for agricultural purposes because water availability is limited. Water quality varies from excellent in mountain headwater streams to poor in lower stream reaches and terminal lakes. Principal pollutants are salts, sediment, nutrients, and heat. Flooding is a serious and widespread problem. Other important water-related issues stem from institutional and financial arrangements.

Projections for the year 2000 suggest a 16 percent decrease in irrigation water usage. Projections for other competing usages in the region, however, show tremendous increases by the year 2000. Water use for mineral mining is projected to increase by 85 to 258 percent, while the expected increase for domestic and commercial uses is 40 to 145 percent over the same time period. With the projected 61 percent increase in population by the year 2000, the water resources of the region will be subject to intense stress. Alternatively, irrigation supplies would have to be diverted to meet the growing needs of the population and industry. Any water scarcity would have a direct bearing not only on the present industries but also any new potential industrial and commercial development. This would strongly effect the economy of the region.

The Pacific Northwest Region

The Pacific Northwest region occupies 110,919 square miles in the northwestern United States. The region as a whole has an abundant supply of water on an average annual basis. This supply, however, is not equally distributed throughout the year or throughout the region. In some areas, the inadequacy of surface water supplies is compensated for by the presence of significant groundwater supplies. In many areas, however, particularly east of the Cascade Range, the lack of adequate supplies both surface and groundwater results in seasonal shortages of water, particularly for use in irrigation, resulting in conflicts between competing instream and offstream uses.

Irrigation is the principal offstream use of water withdrawals while fish life, recreation, hydroelectric power, and navigation are the principal instream uses. During the summer, conflicts exist between the need for irrigation and the need for sufficient streamflows to maintain high water quality for the salmon fishery. Additional reservoirs can only be constructed in prime wildlife habitats or areas of high scenic value. Many water quality problems have been remedied already; major remaining difficulties are associated with enrichment of streamflow, sedimentation, and estuarine pollution. Major land use conflicts occur between development and conservation uses. The legal status of water flowing through Federal reserved lands and Indian reservations is unclear.

The California Region

The California region includes about 164,892 square miles with 1,050 miles of coastline. It includes the State of California and Klamath County, Oregon. Water supplies are poorly distributed in place and time with respect to need. Areas of water surpluses are in the northern part of the region, while areas of primary water demand are in the central and southern portions. Similarly, the largest irrigation demand occurs in later summer, while peak supply occurs in the winter. Reservoir storage and extensive conveyance facilities have been developed to permit effective use of surface water. Groundwater has also been widely developed. Fresh water withdrawals are mainly for irrigation.

One of the region's major concerns is the discrepant distribution of water supplies. The quality of most of the water in the region is superior to the average quality of waters in the nation, but ranges from extremely high in alpine lakes to low along the southern coast and in the lower parts of closed basins. Erosion and sedimentation, flooding, shortages of groundwater, and needs for recreational water surface area and drainage are problems faced by various subareas in the region. Other major issues in the region include allocation of limited inland waters for power plant cooling, water rights, wastewater reclamation and environmental protection.

It is projected that by 2000 the irrigated acreage in California would increase from 9 to over 10 million acres, and that the total amount of water used for irrigation will also

increase significantly. In areas of water scarcity this will result in competing uses of water. This could directly affect the economy of the region which strongly depends upon the availability of water to produce food and fiber both for domestic consumption and for exports. However, surface water in California is generally in short supply and any irrigation expansion will generally come from groundwaters that are already being mined and severely depleted in many areas. Moreover, irrigation with groundwater ultimately affects streamflow impacting on such uses as navigation, fish, wildlife and recreation, maintenance, waste assimilation or energy development.

With increasing population, various allied activities such as manufacturing, power production, domestic and commercial usage of water and recreation are expected to show increases. Among these, the need for energy production is most critical.

The Caribbean Region

Puerto Rico is the largest of the two subbasins of the Caribbean region and has a territory of about 3,435 square miles. The U. S. Virgin Islands consist of an area of about 132 square miles. Most of the rivers in Puerto Rico are short in length, and none are very large in terms of size or flow. The largest river, the Rio Grande de Loiza, has a drainage area of only 310 square miles. Streamflow in the Virgin Islands is ephemeral, and stream channels respond quickly to rainfall due to the extremely steep topography and tiny watershed areas.

Because of the lack of island-wide distribution systems in Puerto Rico, water supplies which are ample overall cannot fulfill the needs of heavy demand areas. If managed wisely, Puerto Rico's water resources are sufficient to support significantly increased levels of population and economic activity. Water quality is a major concern as surface waters are used as waste depositories and for domestic and agricultural needs. Flooding, erosion and sedimentation are experienced throughout the region.

The Virgin Islands have very limited water supplies. Water sources include raw and desalinated sea water, rainwater collection, wastewater recycling, and barging. The distribution facilities are very poor, and the desalination plants experience frequent failures.

SURFACE WATER SUPPLIES

Surface waters comprise rivers, streams, lakes, swamps, marshes, and manmade reservoirs. Approximately 2/3 of all water supplies is withdrawn from surface sources. Surface supplies are replenished primarily through precipitation. On an annual basis, 4,200 billion gallons per day of precipitation occurs, primarily as rain. Of this amount, 2,800 BGD are "lost" to evaporation, leaving approximately 1,400 BGD available for surface water replenishment, groundwater recharge, etc. There is extreme seasonal and regional variability in precipitation. For example, average annual streamflow varies from less than 4 inches to more than 200 inches across the outermost U.S. The direct result of varying precipitation is localized droughts.

Precipitation enters surface waters directly and

indirectly. Indirect replenishment is due to the runoff that occurs when rainwater saturates the surface material and drains into a nearby water body. Drainage occurs both over the and through the ground. Since the surface area of water bodies is considerably smaller than that of the land, most replenishment is via runoff.

The surface over which runoff occurs determines, in large part, the quality of the water entering surface waters. Similarly, air pollutants affect the quality of the rainfall (e.g. acid rain). The combined effect of precipitation as a result of a polluted atmosphere and land forms, rich in toxic and hazardous substances, is contamination of surface waters. For example, the effects of acid rain are just being learned. The effects of runoff containing pesticides as well as siltation from urban areas and cities are becoming better understood.

The surface waters of the United States have, for many years, been used as convenient and inexpensive dumping grounds for waste resulting from domestic and industrial activities. Federal legislation to control these sources of pollution was considerably expanded in the 1970's. Expansion included the promulgation of specific treatment requirements for municipal and industrial discharges, together with Federal assistance for planning to help avoid/prohibit harmful discharges.

The result of this massive effort at pollution control is a stabilization in the rate at which surface water

bodies are being contaminated. As new knowledge was gained on water pollution, the awareness of the extent of existing pollution increased. Today, pollution of water bodies is stabilized, but progress toward the desired goal of zero discharge is slow.

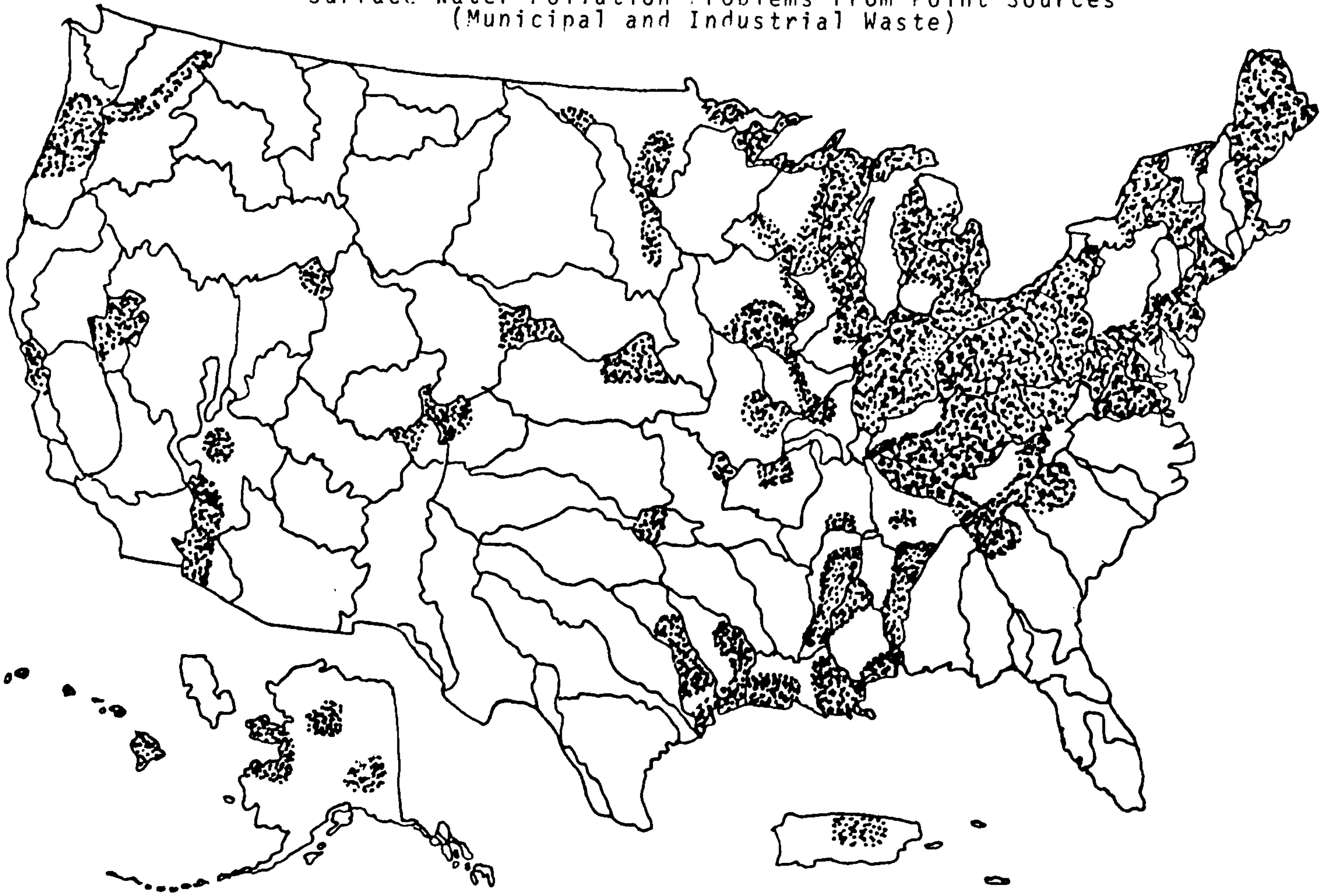
Surface water pollution from point sources affects approximately one-third of the U. S., mostly concentrated east of the Mississippi River. Primary contaminants are coliform bacteria, toxic substances, heavy metals, nutrients and heat. Figure 3-5 shows the regions of the U. S. affected.

Surface water pollution from non-point sources affects specific areas of the U. S. primarily the northeast and central western parts of the country. Primary contaminants are leachates from waste disposal areas and herbicides, pesticides and other chemicals from agriculture. Figure 3-6 shows the regions of the U. S. affected.

An effect of both point and non-point sources of pollution into surface lakes and reservoirs is eutrophication. Eutrophication is the process by which surface water bodies become enriched with nutrients (carbon, nitrogen and phosphorus). The effect is the proliferation of aquatic plants to the point where they deplete oxygen during the absence of photosynthesis. Oxygen depletion is further accelerated by discharges. The result of oxygen depletion is death of aquatic plants and animals, with consequent decay and odor. Eutrophication affects a large portion of the U. S. as shown in Figure 3-7.

FIGURE 3-5

Surface Water Pollution Problems From Point Sources
(Municipal and Industrial Waste)

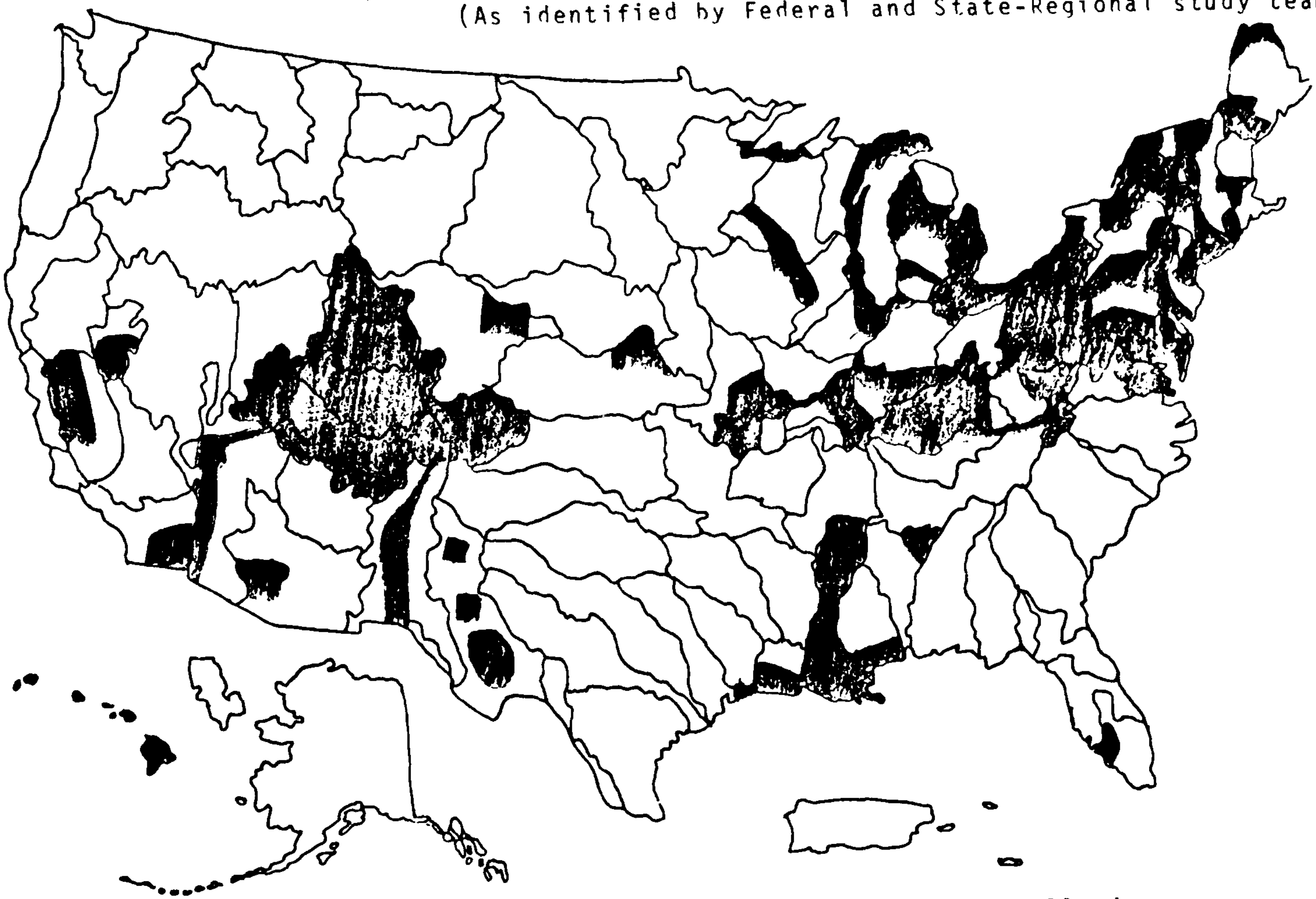


Area in which significant surface water pollution from point sources is occurring.

Unshaded area may not be problem-free, but the problem was not considered major.

FIGURE 3-6

Surface Water Pollution Problems from Nonpoint Sources (dispersed)
(As identified by Federal and State-Regional study teams)

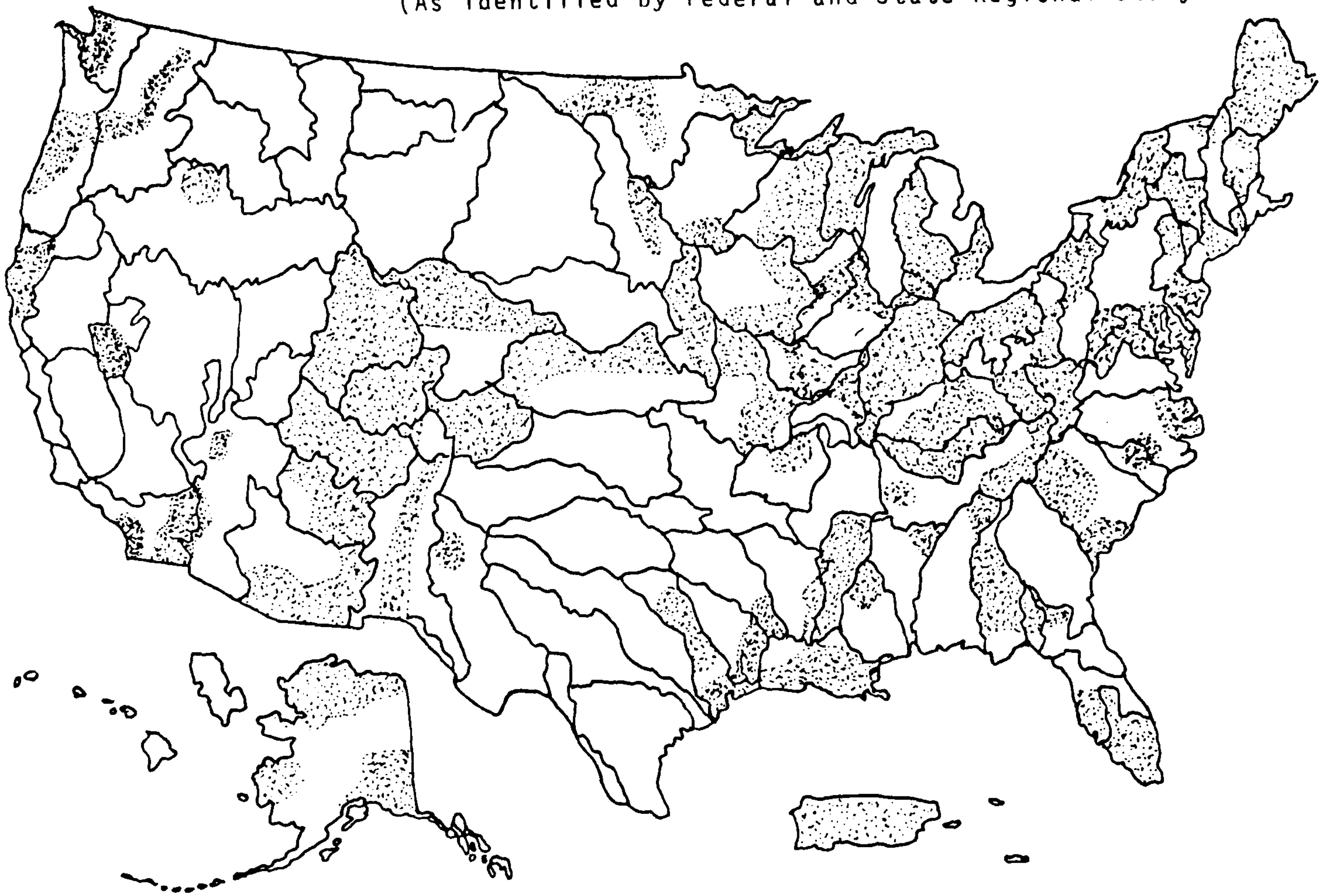


Area in which significant surface-water pollution from nonpoint sources is occurring.

Unshaded area may not be problem-free, but the problem was not considered major.

FIGURE 3-7

Surface-water Pollution Problems-Eutrophication
(As identified by Federal and State-Regional Study Teams)



Area in which significant eutrophication of manmade and natural water bodies is occurring.

Unshaded area may not be problem-free, but the problem was not considered major.

Superposition of the three Figures shows that almost all of the surface water bodies of the U. S. are subject to pollution. Federal and state legislation and programs have at least stopped the increase of pollution and brought about a trend toward the control of all discharges, both point and non-point sources. This trend will accelerate over the next twenty years as more stringent controls are made possible through technology, conservation and economic incentives (and disincentives).

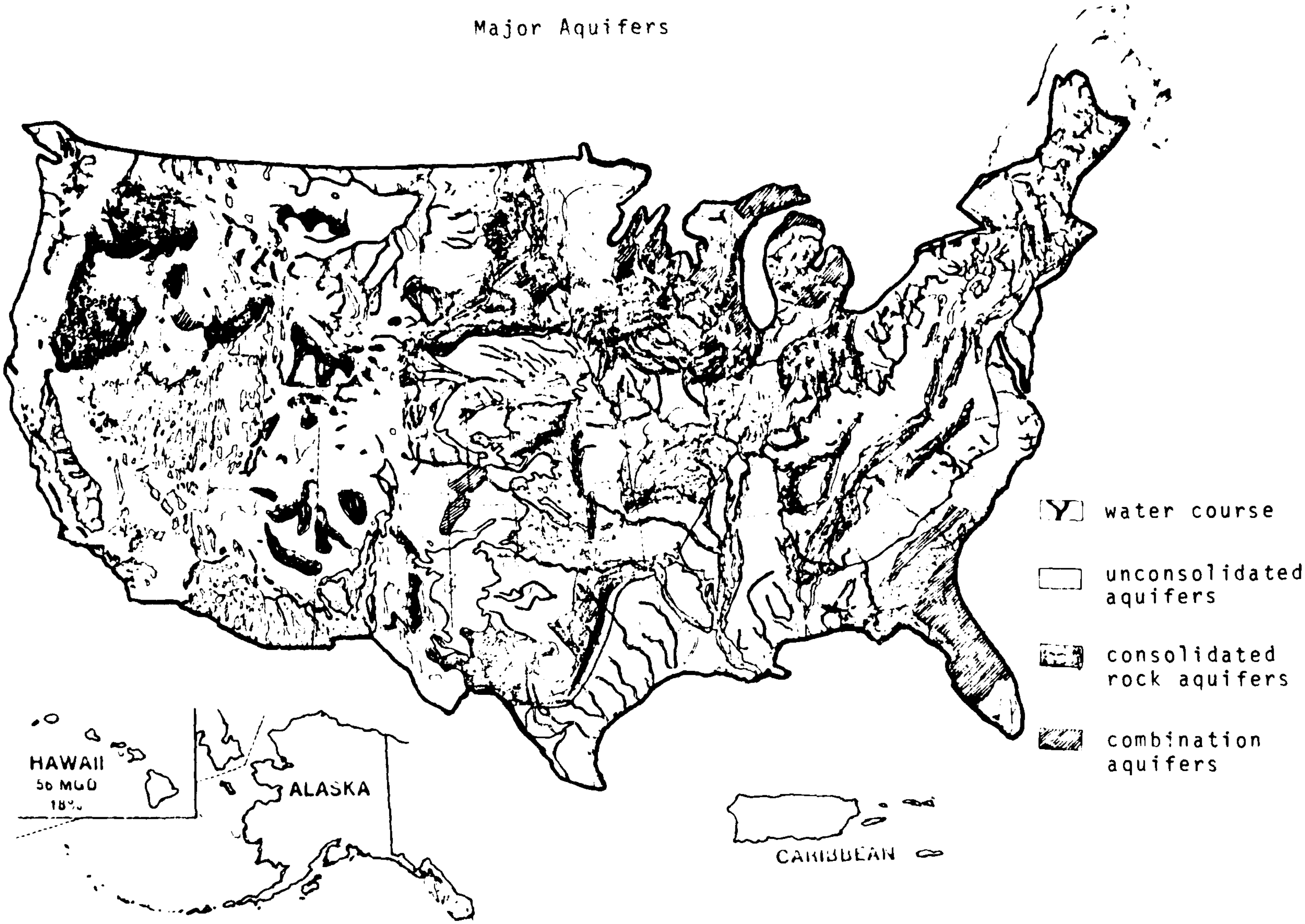
GROUNDWATER SUPPLIES

Groundwater is subsurface water that occurs in soils and geologic formations that are fully saturated. The groundwaters of the United States are a vast resource estimated to have a volume greater than all the surface waters, and more than the total capacity of all the Nation's lakes and reservoirs (including the Great Lakes). This volume is equivalent to about 35 years of surface runoff. Figure 3-8 shows the physiographic distribution of the Nation's groundwater formation.

The physical characteristics of groundwater aquifers vary widely. A large number of aquifers are located near (within 2,500 feet) the surface of the earth. They are extensive and thick in some places, deep and thin in others. Some of these groundwater reservoirs receive ample replenishment from rain and snow, while others receive small or even

FIGURE 3-8

Major Aquifers



negligible recharge. About 30 percent of the Nation's streamflows in an average year is groundwater that emerges as natural springs or other seepage. In turn, seepage from streams, rivers, canals and reservoirs is a principal source of groundwater recharge. During years with subnormal precipitation, most of the flow in many smaller streams in low flow months comes from the groundwater.

The interaction of surface flow and groundwater is extemely important. Moreover, it is important to know the amount of water in underground storage, its quality, the amount considered readily available, the amount currently being withdrawn, and the rate of annual recharge. Withdrawals in excess of annual recharge is termed groundwater "mining".

Of the 100 billion acre feet or 35 x 10^6 billion gallons of groundwater within 2500 feet of earth's surface half is considered to be extractable if no consideration is given to the resulting effect on stream flow, the environmental impacts and the costs of extraction. Presently, the Nation is mining groundwater at a rate of 21 billion gallons per day. The principal use of mined water is for irrigated agriculture. The impacts of such excessive withdrawals include declining and cessation of yield from production wells, land subsidence, declining spring and stream flow and salt water intrusion. Regions of the United States already

experiencing groundwater depletion problems are shown in Figure 3-9.

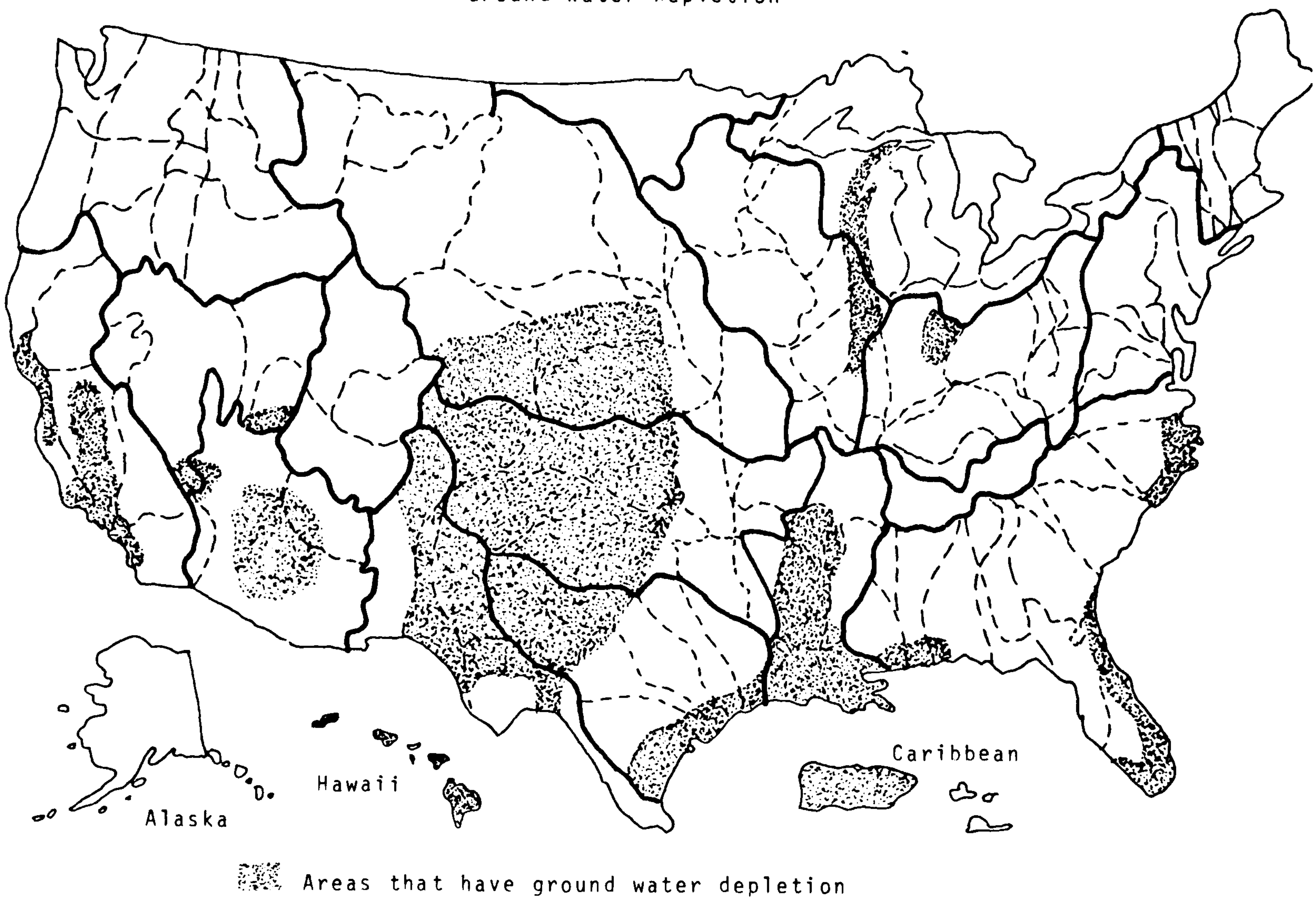
Groundwater supplies represent vast storage potential with an estimated yield of 4550 million cubic meters per day. However, with indiscriminate use, these resources could be depleted, as has happened in certain areas of the United States. Therefore, in any feasibility evaluation, more attention is given to the factors that endanger the resource rather than the potential of the resource itself.

Contamination is the major way in which the resource is being lost. As a result of stream pollution and waste disposal, the groundwater environment is being contaminated with chemicals. Current data indicate that in the United States there are at least 17 million waste disposal facilities resulting in more than 65 billion cubic meters of leachate into groundwater each year. Waste disposal from agriculture is the most dominant factor. Agricultural activities that cause degradation of groundwater quality include application of fertilizers and pesticides and the storage and disposal of livestock or fowl waste on land.

As a result, vast subsurface reservoirs of groundwater are becoming contaminated. Problems of groundwater contamination are difficult to overcome. Because of the heterogeneities inherent in subsurface systems, zones of degraded groundwater can be very difficult to locate and purify. By the time subsurface pollution is identified, it is often too late to apply remedial measures.

FIGURE 3-9

Ground Water Depletion

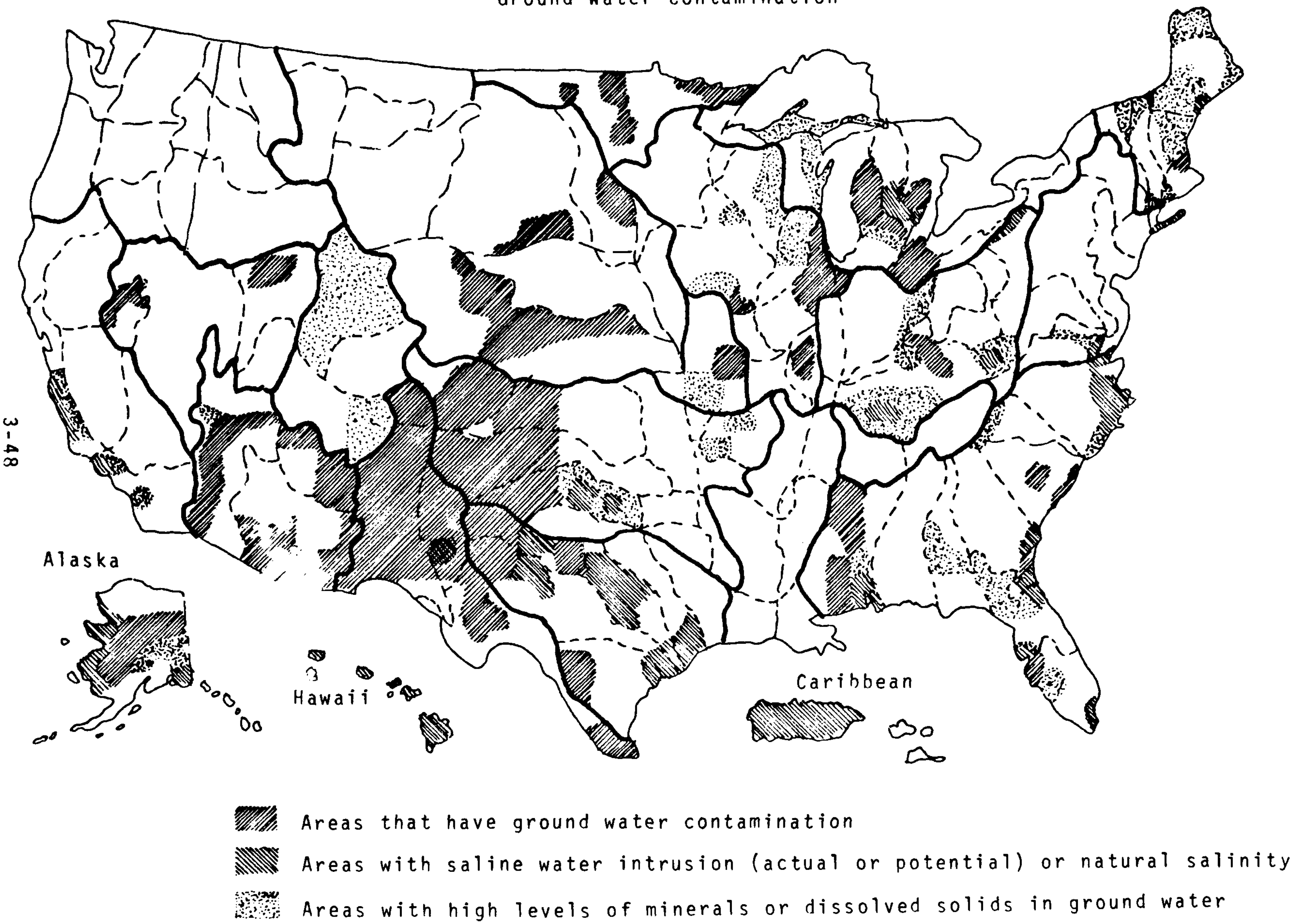


Sewage disposal on land, including septic tank and cesspools are sources of groundwater contamination. Twenty-nine percent of the U. S. population disposes of its domestic waste through septic systems. Other significant contributors of groundwater contamination include petroleum leakage and spills, disposal of radioactive waste, deepwell disposal of liquid wastes, seepage from industrial waste lagoons and activities of mining industry. Regions of the United States are already experiencing groundwater contamination. These regions are identified in Figure 3-10

The increasing use of water is causing an accelerated rate of groundwater mining. During 1975, withdrawals resulted in overdrafts amounting to about 78 percent in the Texas Region, 63 percent in Arkansas-White-Red Region, 50 percent in the lower Colorado Region, 30 percent in the Rio Grande Region, 25 percent in the Missouri Region, 11 percent in the California Region and 8 percent in the lower Mississippi Region. The adverse impact of groundwater mining is the non-renewability of the region's resource. Further, such water is the basis of an expanded economy that faces an uncertain future when available groundwater is depleted. The seriousness of this problem is evident in the High Plains area extending from Texas to Nebraska where the annual overdraft is about 14 million acre feet, over one-half of the total U. S. overdraft in 1975, and an amount that equals the natural flow of the Colorado River.

FIGURE 3-10

Ground Water Contamination



Apart from reducing withdrawal rates, conservation practices and improved use efficiency may extend groundwater resources. For example, irrigated agriculture presently accounts for 46 percent of the total national withdrawals of water and 81 percent of the consumptive use. Recent reports indicate that through conservation and management practices, a potential savings of 20-30 percent (30-45 billion gallons per day) could be realized. Improvements in the off-farm delivery systems, such as lined and covered canals, monitoring and scheduling of releases, and automated weirs and gates, could further reduce groundwater use by as much as 10 percent.

Removal of large amounts of groundwater can cause land subsidence. In such situations, the elevation of the surface may drop several feet over a relatively large area. Low lying coastal areas are particularly vulnerable to periodic flooding in areas that previously were above tidal effects. Subsidence can also cause structural damage. Fissures caused by dewatering have caused both structural failures and pollution incidents: buildings have been damaged; highways and railroads have developed alignment problems; and fissures have allowed the direct entry of polluted surface water.

When groundwater is pumped from aquifers that are in hydraulic connection with the sea, the gradients that are set up may induce a flow of salt water towards the well and thus may contaminate fresh water supplies. Such changes

have occurred in the Biscayne aquifer of Southeastern Florida.

In 1965, irrigation comprised 44 percent of all water used and 83 percent of the water consumed in the United States. A consumption percentage of 70 has been projected for the year 2000. However, according to another assessment consumptive use of water for irrigation will expand from 86 BGD to 93 BGD in the year 2000. Currently water available for irrigation in the humid eastern water resource region is generally adequate for acreage irrigated in 1975 and is expected to remain adequate for the increased area of land to be irrigated in 2000. Temporary shortages may occur during periods of drought. Any shortages are likely to be localized and would probably be met with local resources. In addition, management practices and conservation, including wastewater recycle and reuse, could reduce this demand.

CHAPTER 4 GOVERNMENT WATER MANAGEMENT

FEDERAL LEVEL

Normal Agency Responsibilities

There are 25 different federal agencies dealing with the management of water. Combined they spend more than $10 billion per year. The functions performed by each federal agency with budget responsibility for water planning, management and operations are described below.

- Department of the Interior has the lead responsibilities in water resources research and data collection; desalination; conservation of and development on public lands; studies of outdoor recreation; administration of certain wild and scenic rivers, sports fisheries, and wildlife and their habitat, and endangered species; weather modification; and development and operation of irrigation and multipurpose water resources projects. These functions are primarily carried out through the Office of Water Research and Technology (OWRT) of the U. S. Geological Survey.

- The Office of Water Research and Technology (OWRT) was authorized by the Water Research and Development Act of 1978 to develop new or improved technology and methods for resolvin existing and projected state, regional or nationwide resource problems relating to supply. OWRT supports a network of 54 individual water resource research institutes, located at each State Land Grant University, and in the District of Columbia,

Guam, the Virgin Islands and Puerto Rico. Through this network, OWRT supports training, research, technology development and information dissemination to local, state, regional and national water investigators and policy makers.

- <u>U. S. Geological Survey</u> provides technical information on U. S. resources including water. It has networks of staging stations on major waterways and acquires/disseminates monitored data on both surface and ground water.

- <u>The Bureau of Reclamation</u> (BR) was initially established in 1902 to reclaim the arid and semiarid land of the 17 contiguous western states through massive irrigation projects. Since then, the Bureau's responsibility has grown to include developing multipurpose water projects to meet the diverse needs of expanding population and economy. Among its diversified responsibilities are municipal and industrial water supply, irrigation, hydropower generation, flood control, streamflow regulation, outdoor recreation, fish and wildlife enhancement and water quality improvements.

- <u>Environmental Protection Agency</u>, in cooperation with state and local governments and industry, is concerned with the abatement of water pollution and enhancement of the water quality of rivers and bodies of water, and makes financial grants to state and local governments for the administration of related water quality programs to initiate and coordinate planning, including the construction of publicly-owned wastewater treatment plants. It establishes and enforces standards for the discharge of effluents to receiving waters.

- <u>Department of Agriculture</u> is involved in the management of national forests for their multiple uses, products, and

services; watershed treatment and management; small watershed projects for flood control, water supply, irrigation, drainage, recreation, fish and wildlife, erosion and sediment control, and water quality management; river basin surveys and investigations; economic analyses and projections or rural activities; credit, cost sharing, and technical assistance to farmers for installation of soil and water conservation practices and to rural communities for water supply and sewerage facilities; and supporting research.

- Department of the Army develops plans for beach protection, flood control, navigation, and multiple-purpose projects; constructs, operates, and maintains project facilities; regulates the use of navigable waters of the United States with respect to dredging and obstructions to navigation; and provides state and local interests with floodplain information.

- Department of Commerce conducts hydrometeorological studies; provides river and flood forecast and warning services; administers a coastal zone grant program; is responsible for studies of living marine resources that include those within estuaries and coastal areas; performs business and industrial water requirement analyses; projects economic activity; takes census of a broad range of water uses; and conducts supporting research.

- Department of Energy makes studies of the power phases of river basin development; licenses and regulates non-federal hydroelectric power plants; markets hydroelectric power generated at federal plants; and, in cooperation with the Water Resources [illegible], assesses the impacts and requirements of water for [illegible] development.

- <u>Department of Housing and Urban Development</u> is concerned primarily with the municipal and urban aspects of water and related land resources, including flood insurance and urban hydrology. It makes financial grants to states and to metropolitan and urban communities for comprehensive planning and community development that may include support for water and sewer facilities, open space, recreational areas, and historic and esthetic preservation.

- <u>Department of Transportation</u> is involved with the navigation, marine safety, pollution by vessels, and highway and bridge aspects of water resources development.

- <u>Council on Environmental Quality</u> formulates and recommends national policies to promote the improvement of the quality of the environment. The Council performs a continuing analysis of changes or trends in the national environment and assists the President in the preparation of the annual Environmental Quality Report to the Congress.

- <u>Tennessee Valley Authority</u>, a corporation of the Federal Government, was established by Congress in 1933 as a regional resource development agency. TVA assignments in the Tennessee drainage basin and adjoining territory are to control flood waters of the Tennessee River, improve navigation on the Tennessee River, generate and sell electricity, encourage agricultural and industrial development, promote reforestation, and advance the economic and social well-being of the people.

- <u>Water Resources Council (WRC)</u> was established by the Water Resources Planning Act of 1965 (P.L. 89-80, 79 Stat. 244,

as amended) to implement a policy of water conservation including the development and utilization of water and related land resources of the United States. The Council's members are drawn from the President's Cabinet and key federal agencies. Members of the Council are the Secretaries of the Departments of Agriculture, Army, Commerce, Energy, Housing and Urban Development, Interior, and Transportation, and the Administrator of the Environmental Protection Agency. Observers are the Director of the Office of Management and Budget, the Attorney General, the Chairman of the Council on Environmental Quality, the Chairman of the Tennessee Valley Authority, the Chairmen and Vice Chairmen of the River Basin Commissions, Commissioners of Interstate Compact Commissions, and Chairmen of Interagency Committees.

The Council continuously monitors the nation's water supply and needs, periodically reporting its findings in a national assessment of water resources. It maintains a continuous program for preparation of regional and river basin plans to ensure that interstate water issues are properly considered. In addition, the Council administers planning procedures that assure the public that water projects are economically and environmentally sound. Working with river basin commissions, interagency committees and the states, the Council helps to finance and to foster state-federal cooperation and coordination in all aspects of water resource management.

The Council determines the principles, standards and procedures which govern the federal water programs, while appraising

the adequacy of existing and proposed programs and recommending necessary improvements in them. These standards apply to the planning and evaluation of the effects of programs and activities carried out with federal financial or technical assistance including programs of other federal agencies, such as

- Corps of Engineers
- Bureau of Reclamation
- Federally constructed watershed and water and land programs
- National parks and recreation areas
- Wild, scenic, recreation rivers and wilderness areas
- Wetland and estuary projects and coastal zones
- Federal waterfowl refuges
- Tennessee Valley Authority
- Federal assistance to state and local government sponsored watershed and water and land resource programs (Watershed Protection and Flood Prevention Projects and Resource Conservation and Development Projects).

- Office of Management Budget assists in developing efficient implementation and coordination mechanisms for government programs and policies; assists the President by clearing departmental advice on proposed legislative enactments; and promotes evaluations to assist the President by ensuring effective program performance and efficiency.

- The Attorney General, as head of the Department of Justice and Chief Law Officer of the Federal Government, represents the United States in legal matters, generally including those concerning water and related lands, and gives advice and opinions to the President and to the heads of the Executive Departments as requested.

Federal Emergency Management Agency (FEMA)

FEMA was created by Reorganization Plan No. 3 of 1978 (effective April 1, 1979, pursuant to Executive Order 12127 of March 3, 1979). The plan collated under FEMA broad emergency responsibilities including:

- Department of Commerce's Fire Administration and National Academy for Fire Prevention and Control;
- Federal food, riot and crime insurance programs;
- Department of Housing and Urban Development's Federal Insurance Administration;
- Functions of the Civil Defense Preparedness Agency in the Department of Defense; and
- Federal Disaster Assistance Administration at the Department of Housing and Urban Development.

In water-related emergencies, FEMA acts only in instances of declared emergency situations, such as nuclear fallout, flood disaster, etc. FEMA may respond independently or more typically with the other federal agencies identified above to assist states.

STATE LEVEL

The role of the states in water management has generally been subservient to and dependent upon federal policy. States are, however, becoming the focal point for water resource management.

The Water Resources Council (WRC) is assisting states in water and related land resources planning and management. In order to foster joint state-federal cooperation and coordination in water resources planning and management programs, WRC establishes

and assists river basin commissions, interagency committees and various coordinating groups. A brief description of their roles is described below.

- <u>River Basin Commissions</u>. To meet the need for broad participation in planning, the Water Resources Planning Act provides for the establishment of federal-state river basin commissions on request of the state and the recommendation of the Water Resources Council. The affected States and federal agencies have representatives on these commissions. The Chairman is appointed by the President and the Vice Chairman is elected by the states. Commissions have been established for the Pacific Northwest, the Great Lakes, the Ohio River, the Missouri River, the Upper Mississippi River, and the New England River basins. Commission functions are:

    - To serve as the principal coordinating agency for water and related land management plans

    - To prepare and keep current a comprehensive coordinated joint federal-state plan for water and related land resources development within the basin

    - To recommend priorities for data collection and for investigations, planning, and construction of projects

    - To foster and undertake such studies as are necessary in preparing and maintaining the comprehensive plan

    - To submit to the Water Resources Council a comprehensive plan and recommendations for implementing the plan.

- <u>Interstate Compact Commissions</u>. The Federal-Interstate Compact Commission for the Delaware River Basin was established

by the legislatures of four states and the Congress in 1961. It is the first compact in which the United States is a signatory party. The Delaware River Basin Commission, created by compact, is composed of representatives of the four basin states and the Federal Government. It is vested with broad powers to manage and control the water and related land resources of the entire Delaware Basin. Significant activities have been: the handling of interstate conflicts about short water supplies during a prolonged drought; leadership in developing water quality standards; and careful review and approval of hundreds of individual water facilities including wells, industrial installations and municipal water supply and sewerage systems to ensure coordinated development. Although the Commission is empowered to construct and operate water projects, it has not as yet done so. A similar federal-interstate compact has been established for the Susquehanna River Basin. Federal-interstate compacts have been proposed for other river basins.

- Interagency Committees. Before 1965 and the establishment of the U.S. Water Resources Council, interagency committees were created by an *ad hoc* council. After 1965, some of the committees were replaced by river basin commissions. Three interagency committees--Pacific Southwest, Arkansas-White-Red Rivers, and Southeastern River basins--remain and continue to operate under the aegis of the Water Resources Council. These committees do not have legal status (presidentially-appointed full-time Chairman and central staff) but have about the same

representation (federal and state) as the river basin commissions. Their functions, however, are usually limited to serving as a coordination entity and discussion forum.

In the President's June 1978 message, several initiatives are provided in the revised water policy message to strengthen federal-state relations and to develop a new, creative partnership. Technical advice, long-range studies of state's water needs, planning of reservoirs and flood control programs, ground water studies, assistance with soil survey and flood plain services are among the activities that are now strengthened. Specific activities include:

- A substantial increase from $3 million to $25 million annually in the funding of state water planning under the existing 50%-50% matching program administered by the Water Resources Council (WRC). State water planning would integrate water management and implementation programs which emphasize water conservation and which are tailored to each state's needs including assessment of water delivery system rehabilitation needs and development of programs to protect and manage ground water and instream flows.

- Preparation of legislation to provide $25 million annually in 50%-50% matching grant assistance to states to implement water conservation technical assistance programs. These funds could be passed through to counties and cities for use in urban or rural water conservation programs. This program will be administered by the Water Resources Council in conjunction with matching grants for water resources planning.

- Working with governors to create a Task Force of federal, state, county, city and other local officials to continue to address water-related problems. New administrative actions and legislative proposals are designed to

initiate sound water management policy at the national level. However, the Federal Government must work closely with the states, and with local governments as well, to continue identifying and examining water-related problems. This Task Force will be a continuing guide to implementation of the water policy reforms and will ensure that the state and local role in our nation's water policy is constant and meaninful.

An instruction to federal agencies to work promptly and expeditiously to inventory and quantify federal reserved and Indian water rights. In several areas of the country, states have been unable to allocate water because these rights have not been determined. This quantification effort should focus first on high priority areas, should involve close consultation with the states and water users and should emphasize negotiations rather than litigation wherever possible.

LOCAL LEVEL

Most supply and demand water problems will occur and must be solved at the local level. Pollution control legislation and programs at the federal level all indicate a focus to local problem solution, by local governments, during the mid to late 1980's. The revised federal water policy strengthens the role of the local agencies in planning for and implementing water projects, and a nationwide emphasis on conservation as a primary remedial action.

POLICY CHANGES

In June 1978, President Carter revised current water policy extant since 1976. This new water policy is designed to achieve four basic objectives:

- improved planning and efficient management of federal water programs which will permit the completion of necessary water projects that are cost effective, safe and environmentally sound;
- a new national emphasis on water conservation;
- enhanced federal-state cooperation in water policy and planning; and
- increased attention to environmental quality.

The policy is aimed at removing and/or mitigating inefficiencies and environmental problems in various water programs, and was the result of a year-long review initiated in 1977. The review was carried out by the Department of the Interior, the Council on Environmental Quality, and the Office of Management and Budget under the chairmanship of Secretary of the Interior. The review identified the following major problems:

- Despite serious water supply problems in several parts of the country, there is no national emphasis on water conservation.

- There are wide variations in the techniques used to estimate benefits and costs in planning federal water projects.

- Some of these water projects are unsafe, economically unjustified, or environmentally destructive and do not reflect adequate compliance with existing laws and regulations.

The Water Policy Message of 1978 was directed to all executive departments and agencies. The water storage and transfer development projects of the Army Corps of Engineers, the Bureau of Reclamation, the Soil Conservation Service and the Tennessee Valley Authority are most affected, since traditionally they are directly involved in planning for and constructing reservoirs and conveyance systems. The activities of these four agencies account for nearly $4 billion in federal funds each year. Most of the remainder of federal funds for water programs is spent for grants and loans (i.e., the $5 billion municipal wastewater treatment program of EPA) to state and local governments.

Federal policies for water management reflect energy and environmental objectives as expressed in legislative or administrative action. Federal policies further represent the past resolution of conflicting uses and competing claims.

To investigate the effects of changes in water policy, budget or expenditures for water resource projects,were examined. A graph of historic outlay data from 1930 to 1954

by decades, shown in Figure 4-1, indicates that federal spending for water resource developments increased seven times to a cumulative total of more than $14 billion. More recent data are presented in Table 4-1 and shown graphically in Figure 4-2. These data show that expenditures are projected to increase at a rate of 27% per year. Allowing for inflation, this would indicate a real growth in expenditures of from 10 to 15 percent per year. The growth in expenditures appears to be independent of national policy changes. The primary effect of policy change is thus to reorient the direction and focus of water resource projects and not to curtail expenditures.

It is interesting to compare the rate of projected expenditures to the rate of expected water scarcity problems. The data of the WRC show an increase of from 21 affected basins in 1975 to 39 affected regions in 2000. These data are graphically presented in Figure 4-3, along with the forecast of budget expenditures from Figure 4-2 The slopes are very similar, especially when the effects of inflation are factored into expenditures, and real growth in outlays is considered.

It appears as though national policy, federal funding, and anticipated water supply problems are fairly consistent. Key elements of this consistency are as follows:

FIGURE 4-1

Federal Spending for Water Resource Development

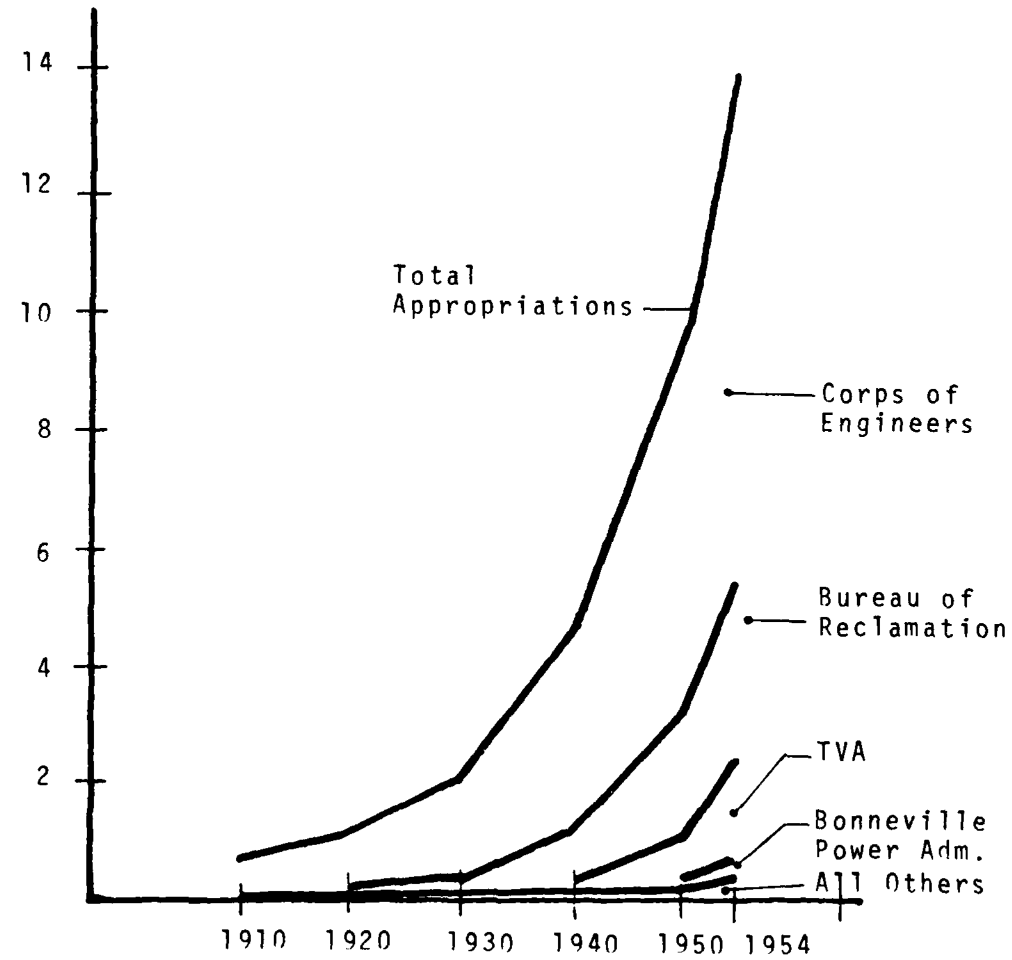


TABLE 4-1 Annual Federal Expenditures For Water Resources

Year	Outlays (Billions)
1971	1.8
1972	1.8
1973	2.2
1974	2.0
1975	2.2
1976	3.0
1977	3.2
1978	3.5
1979	4.1
1980	4.5

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IMPACTS OF WATER SCARCITY ON COAST GUARD MISSION REQUIREMENTS A--ETC(U)
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UNCLASSIFIED USCG-D-43-81 NL

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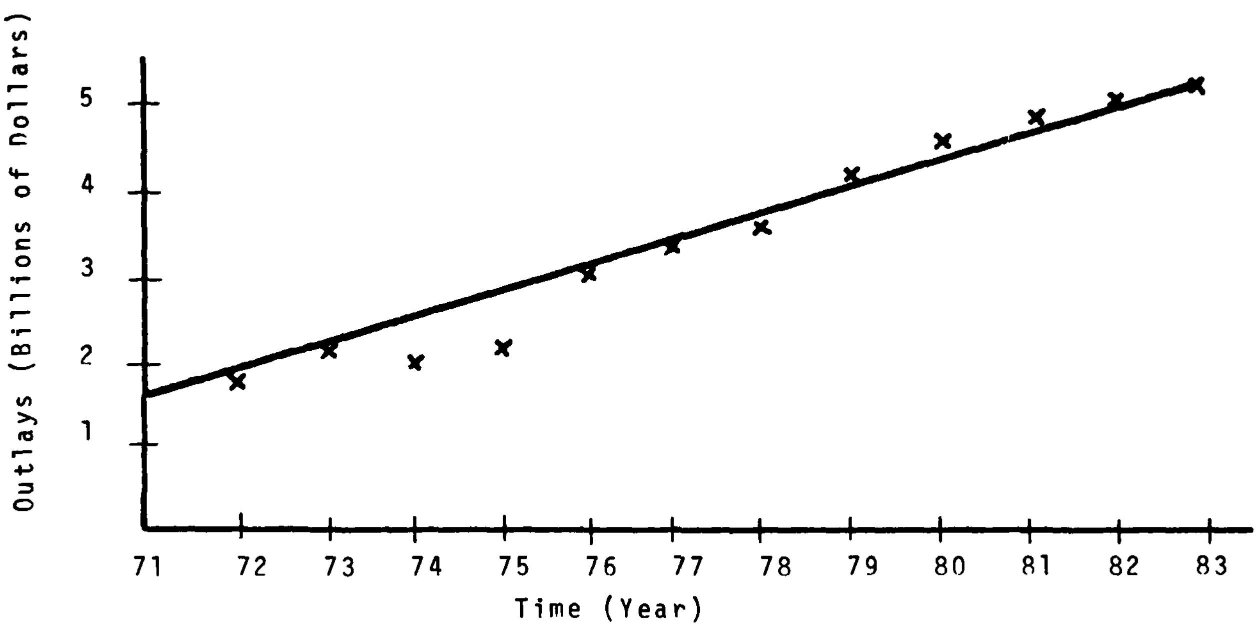
FIGURE 4-2

Base Data and Forecasts of Budget Expenditures



- Water resources will be developed in such a way and at such times as will assure their optimum use. This necessarily will involve the concept that each project must be economically sound.

- Public participation will greatly increase in water resource development.

- Local and regional drainage areas would be among the primary considerations to the development of water resources.

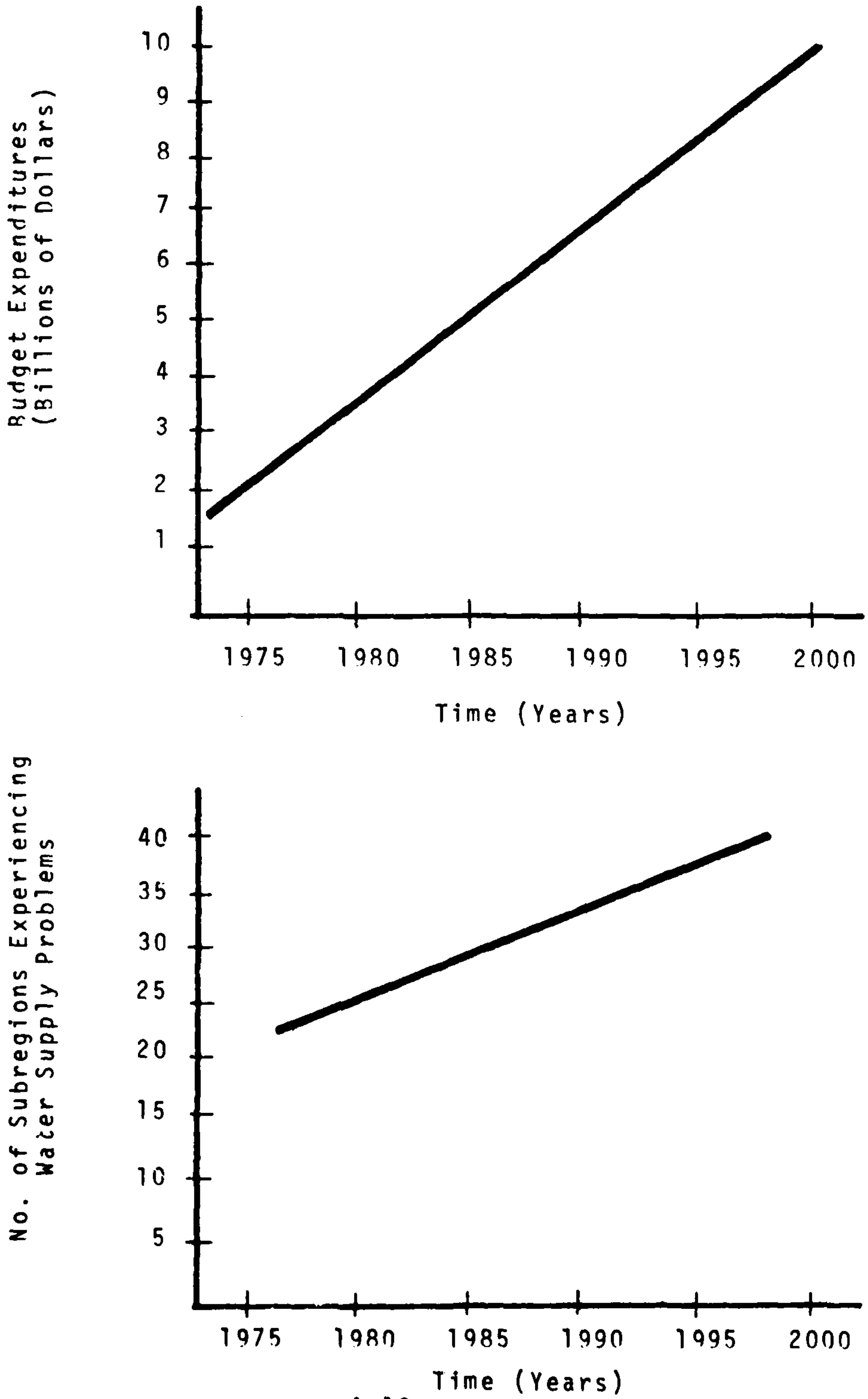
- Water resource conservation, education and research as a means to accomplish certain economic ends would receive greater attention and increased funding.

- Primary responsibility, such as the basic decision for water resource development, may be transferred to local, state and regional levels, while federal responsibility is likely to involve areas of special responsibility and competence.

- Steps to facilitate resolution of controversies surrounding federal reserved water rights and Indian water rights.

FIGURE 4-3

Comparison of Forecast Expenditures with Projected Water Scarcity Problems



CHAPTER 5 TECHNOLOGICAL ADVANCES

Technological advances are those developments that may occur over the next twenty years that could increase the supply of fresh water or affect the demand for fresh water. Technology has been researched according to three general subject areas: modification of supply; water use and reuse; and power generation.

The primary findings from investigations into each of these subject areas are:

- Implementation of technology to increase supply, except for desalination, is improbable.
- Modification of demand patterns, primarily through conservation and management practices, is highly probable.

Descriptions and findings for the individual investigations performed are presented in the following pages.

MODIFICATION OF SUPPLY

Topics of study included weather modification; desalination; water storage and transfer; and transportation of icebergs. General findings are as follows:

- Major advancements for increasing rainfall and other precipitation by weather modification are not expected over the next 20 years. Localized experiments will continue.
- Decisions to establish ocean-based desalination plants will be made by local governments and the number of such plants is expected to approximately double over the next 20 years.
- Large scale water storage and transfer projects will be discouraged at the federal, state and local levels and conservation measures will be adopted.

- No major advancements in transporting icebergs are anticipated. The feasibility of transporting icebergs to North America has not been proven.

Weather Modification

The possibility of weather modification has been of interest to man for centuries. Serious work initiated by the General Electric Laboratory using dry ice to sublimate moisture in cold air led to governmental interest and funding for research on cloud particles and cloud modification. A tri-service group was formed to conduct field programs. This first organized effort to modify the atmosphere in 1947 was termed "Project Cirrus". Since then, a number of federal agencies, universities, and commercial groups have been engaged in laboratory research and field experimentation.

Studies on the effects of cloud seeding were carried on for seven summers during the period 1957-1963 at Ticino, Italy and during the years 1957-1964 in the Santa Catalina Mountains of Arizona. These experiments yielded some similar results but under dissimilar circumstances, i.e., increased rainfall at long distances from the sites.[2,3] This phenomena is still under study. Studies and field experiments continue despite the facts that: there is lack of agreement on measuring success of experiments; and that the cost of experimentation which must be performed within the atmosphere itself is very high.[1]

Laboratory experiments have been successful in small-scale inducement of precipitation. In the atmosphere, unlike the laboratory, however, parameters cannot be controlled and

may change independently and/or interdependently. It is currently impossible to represent a total atmosphere in the laboratory; to establish representative values statistically from measurement of the real atmosphere; and to compare changes in those values when artificial forces are introduced. Additionally, a mass of atmosphere is in motion not only within itself but also within the total atmosphere.

For modification of an airmass to be effective at a given location and time, cloud history must be known. Even then, it is difficult to prove, or disprove, that resulting rainfall was artificially stimulated or augmented rather than natural. Due to the independent and interdependent nature of all parameters and despite the utilization of sophisticated monitoring devices and predictive computer programs, answers are incomplete regarding: when to attempt alteration; how the alteration will function; and what results will be achieved.

Knowledge gained to date may be summarized as follows:

- Modification of the precipitation associated with lifting of a cool, moist airmass as it flows up the side of mountains (orographic lifting) can be accomplished at present when the clouds are at or below $-10^{\circ}C$

- Modification of warm orographic clouds may be developed (the limitation on warm orographic cloud modification arises primarily on connection with universal topographic structures where realistic air flow models will likely prove difficult to develop)

- Some recent field experiments provide strong indications that precipitation from cold convective clouds can be altered under at least some narrow classes of cloud and environmental conditions

- Programs for altering cloud systems are in an early stage of exploration and general application will probably not be achieved in the near future

- The results of field and laboratory programs have demonstrated the possibility of releasing precipitation from cold stratus clouds at any time or place it would have practical value (note that there are unresolved questions regarding the degree or significance of the alterations which can be achieved)

- The physical mechanisms which produce and maintain warm stratus clouds provide poor prospects for significant precipitation from these clouds

- A sound basis exists for altering precipitation from some warm convective clouds

Desalination

The conversion of sea water to fresh water is not a new concept. Since shortly after the advent of steam as a power source for seagoing vessels, ships have been making the fresh water required for boiler feed and for crew and passenger use. In Chile, a sea water conversion facility occupying some 4,000 square yards was put into operation in 1872 and sea water conversion for human use has been effected for many years in Israel, Libya, South Africa, the Persian Gulf area, and the Lesser and Greater Antilles.

During World War II, numerous types of portable and small-scale desalination equipment accompanied the armed forces occupying islands in the southwestern Pacific. Miniature desalination kits for use in life rafts were also developed during this period. Beginning in 1950, growing concern regarding the decrease of fresh water supply (increasing population and

increasing industrial use) became a matter of importance to a large portion of the world.[4] Augmentation of fresh water supplies remains a matter of concern today and promises to become more critical in the future.

The history of conversion of sea water to fresh water clearly indicates the feasibility of the concept. Direct distillation was the first process to be adopted. Distillation remains the principal mechanism today and a number of refinements of the technique have been evolved. Distillation systems presently in use include:

- Single-stage Flash
- Multi-stage Flash
- Thin-film Vertical Tube
- Vertical Tube Evaporator--Multi-stage Flash
- Vertical Tube--Vapor Compression
- Thin-film Horizontal Tube
- Submerged Tube
- Vapor Compression

Concurrent with the evolution of distillation systems, techniques for separation of salts from water by membranes have been developed. The principal membrane processes include:

- Electrodialysis
- Electrodialysis--Reversing
- Reverse Osmosis

The following provides a summary of the status of salt-water conversion:[5]

"According to information gathered, there are about 1500 land-based desalting plants of 25,000 gallons per day or larger capacity in operation or under construction throughout the world as of the beginning of 1977. These plants are capable of producing close to one billion gallons of fresh water daily for municipal and industrial uses. Distillation processes account for 77 percent of total plant capacity and 53 percent of the total number of plants. The balance is almost entirely in membrane processes with freezing accounting for less than one tenth of one percent.

A third of the plants are located in the United States, but their combined capacity totals only about 10 percent of total worldwide plant capacity. Fewer plants are located in the Middle East and North Africa, but their combined capacity amounts to about 55% of the total. Next comes Europe, then Asia sharing together a fourth of the total worldwide plant capacity. Five percent of plant capacity is located in the Caribbean region and the remaining 5% is scattered in the rest of the world.

During the two year period 1975-1976, worldwide sales of 476 new desalting plants of 25,000 gallons per day or larger were reported with a combined capacity of 434 million gallons per day. This compares to 322 plants with a combined capacity of 122 million gallons per day reported as sold during the two-year period 1973-1974. Membrane plants account for about seventy percent of the plants sold during 1975-1976, but their combined capacity is only one-third of the total capacity sold during the period. Distillation plants account for the balance of 1975-1976 sales."

Worldwide development of desalination facilities are graphically shown in Figure 5-1. Operation of desalination facilities began in the United States in 1952. Today there are no off shore plants, but 481 land-based facilities are in operation. A summary of U.S. utilization of desalination facilities is presented in Table 5-1.

FIGURE 5-1

World-Wide Sales of Land-Based Desalting Plants with Capabilities of One Million Gallons Per Day or More

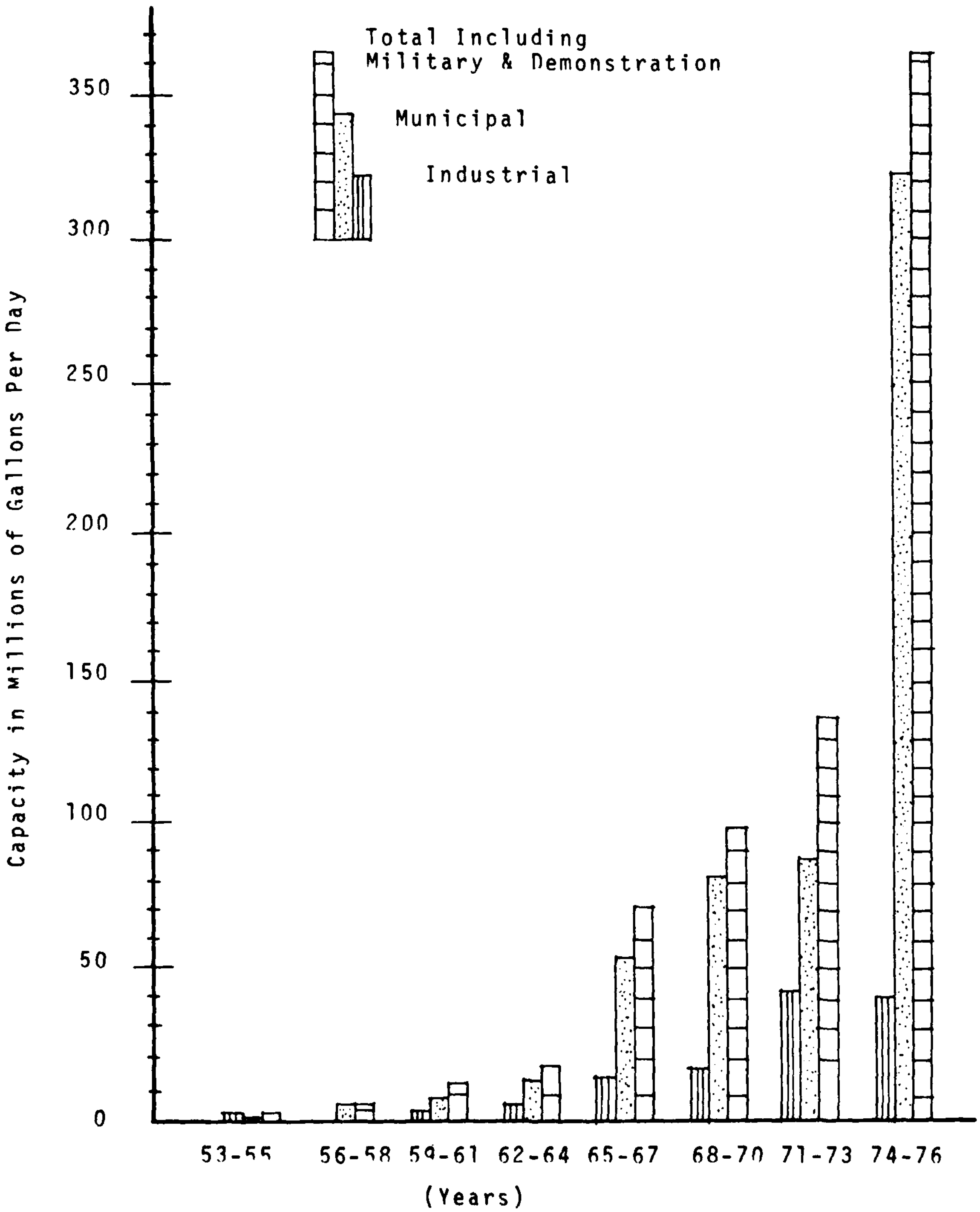


TABLE 5-1 Summary of U.S. Utilization of Desalination Facilities

			Percent Used
SYSTEM	Distillation	Single-stage Flash	.10
		Multi-stage Flash	.015
		Vertical Tube-Vapor Compression	.01
		Submerged Tube	.15
		Vapor Compression	.02
	Membrane	Reverse Osmosis	.67
		Electrodialysis	.02
		Electrodialysis-Reversing	.015
USE		Industry	.49
		Power	.27
		Municipal	.15
		Demonstration Project	.06
		Military	.02
		Tourism	.01
FEED-WATER		Inland Brackish	.88
		Waste Water	.08
		Sea Water	.04
FUEL		Electric	.77
		Coal	.08
		Steam	.07
		Gas	.04
		Oil	.02
		Uranium	.02

A principal deterrent to wide-scale adoption of desalination for water supply is cost. Indications are that large (greater than 2 million gallons per day--MGD) Multi-flash Distillation (MFD) systems are the most economically favorable; however, the price ($1.43/1000 gal.) is still considered high.[6] A goal of the U. S. Government is a maximum cost of $1.00/1000 gal., but today's costs range from $1.43 to $2.69 per thousand gallons. Rising energy costs will contribute to desalination cost competitiveness. The feasibility of using solar energy as a power source, and solar energy in combination with various conventional power sources, is presently in the research stage.

Plants now operating in the U. S. are producing fresh water in the upper portion of the product price scale. The largest facility in this country is 5 MGD capacity. Three percent of all facilities have capacities of 1 MGD or more; four percent have capacities of 0.5 MGD or more; thirty-two percent have capacities of more than 0.1 MGD but less than 0.5 MGD. The remaining 61 percent have capacities of less than 0.1 MGD.[7]

Water Storage and Transfer

Water transfer projects predominate on the West Coast of the United States. The earliest project in California was the Los Angeles Aqueduct, completed in 1913. Investigations and proposals to transfer water from the Sacramento Valley to the San Joaquin Valley began in the early 1870's. The Los Angeles

Aqueduct carried water from the eastern slopes of the Sierra Nevada Mountain to the city. The project cost $24.5 million, including the purchase of land and water rights and the aqueduct construction. The original delivery capacity of the aqueduct was 150,000 acre-feet. In 1970, this capacity was expanded to 320,000 acre-feet, and again in 1968 it was further expanded to deliver 472,000 acre-feet per year.

In 1924, the Metropolitan Water District was formed by several counties in California, including Los Angeles. This District built a 242-mile aqueduct from the Colorado River to the metropolitan area, comprising 92 miles of tunnels, 63 miles of concrete lined canals and 54 miles of concrete conduits. Today the capacity of this system exceeds 1 billion gallons per day.

The City of San Francisco, California, is served by reservoir storage tunnels and pipelines. Water impounded by the O'Shaughnessy Dam located 150 miles away is carried to the city. The dam was completed in 1923, with water delivery beginning in 1934.

Water storage and transfer projects on the east coast are in New York. The present water system for the city consists of three major upland reservoir systems into the Hudson Basin: the Cranton River System, established before 1900, delivering 346,000 acre-feet; the Catskill System, established in 1924, delivering 622,000 acre-feet; and the Delaware System completed in early 1970's, delivering 1.03 million acre-feet.

Short-range water transfers include the use of trucks or vessels to "carry" water. In 1970, 500 year-round haulers supplied 72 million gallons of water to 6000 rural residents in Illinois. The average distance of each haul was 10 miles. Between 1955 and 1970, truck hauling of water has increased by approximately a factor of 10. This form of transfer is expensive and has been restricted to short distances only. No other form of vehicle or vessel transfer of water was identified in the literature.

Technically, water storage and transfer systems are feasible. The creation of impoundments and reservoirs via the construction of dams is straightforward. The construction of aqueducts, tunnels and pipelines is standard practice.

However, economic feasibility is a continuing problem. For example, a study of interbasin water transfer, performed in 1971, concluded:[8]

> "The preponderance of evidence indicates that, except for certain sets of circumstances in so-called 'rescue operations,' the national economic benefits from the use of the water provided would be less than the costs of the transfers. Furthermore, there is evidence that substantial supplies could be obtained from alternative sources at lower costs."

Unfavorable economics are exacerbated by the economics of alternatives to water storage and transfer systems. Alternatives to large-scale water transfer include: reductions in conveyance losses, additional surface development, wastewater reclamation, desalination, vegetative management, evaporation

retardation and transfers from agriculture to high-valued uses. This last alternative recognizes the fact that most basin transfers planned have been primarily for agricultural reasons, including direct use or ground water aquifer recharge. However, it has been estimated (in 1975) that one acre-foot of water will return $50 per year in agriculture, $200 to $300 per year in recreation, and $3,000 to $4,000 per year if used for industry.[9] Further, a distinction is usually made between transfers to maintain existing agriculture or to establish additional crop acreage. The expansion of irrigated acreage may be profitable only under continuing federal subsidies. Also, the developed acreage may displace present uses of that land. The decline of prime farmland, the stabilizing of productivity per acre and the use of food production in balance of payments and foreign policy may offset these impacts. Alternatively, the increase in energy costs amplify them.

Alternatives that involve conservation are promising. It has been estimated that as much as 9 million acre-feet per year could be saved in the western portions of the United States.[9] Similarly, the use of treated sanitary effluent for agricultural and industry source water decreases demand for new transfer systems. In 1971, Los Angeles was reclaiming approximately 16 million gallons per day and using it for ground water aquifer recharge.

Other literature indicates that interbasin transfer of water, including both large and small-scale systems, are

feasible only where a tangible benefit to the donor region could be shown and the diversion (transfer agreement) is cancellable.[10] In terms of benefits, they should be at the exclusive expense of the receiving region and could include some level of flood control or of low stream flow augmentation, both of which would require increased dam and reservoir sizes. As an alternative, cash payments could be made directly to the counties primarily affected by the diversion. Cash payments would be difficult to administer and could lead to endless litigation because of the highly interrelated effects of a diversion schedule on individual communities. Obvious benefits accrue to transfer schemes that involve only flood skimming. However, flood skimming projects are of little benefit to the receiving region unless a large amount of unused storage is available.

Water storage and transfer systems, serving large areas or populations, demonstrate economies of scale. However, it has been shown that, with the exception of storage reservoirs and wastewater treatment facilities, little evidence of actual economies of scale exist.[11]

Benefits derived from the establishment of a water storage and transfer system must equal to and preferably exceed the costs. The value of benefits is difficult to estimate and depends on economics of the use of the transferred water. Economics of use include direct and induced. For example, water transferred for irrigation could induce industrial development,

etc. The placing of a value to benefits, for subsequent comparisons to development cost, is a nebulous act easily confused by statistical procedures, exogenous and indigenous variables and mathematical models. Acceptance of these procedures by the technical community is difficult; acceptance of the results of these procedures by a community opposed to or affected by a water transfer project is impossible.

The environmental impacts of water storage and transfer projects span from the ecological to the social. Ecological impacts include: disruption or perhaps destruction of terrestrial habitat by innundation; modification of stream flow resulting in fish kills or destruction of benthic communities; physical obstructions to migratory pathways; loss of vegetation; and perhaps loss of habitat for threatened or endangered species. Impacts to water quality could include: alterations in the water table of affected areas; increased stream pollution due to decreased flow; increased sedimentation and/or scour of stream bed and banks; and increased fish kills due to supersaturation of waters with oxygen and nitrogen from passing over dams and spillways. Social impacts include recreation and aesthetics, attitudes, increased/decreased economic activity, tax revenue, etc. It is very difficult to segregate social impacts from legal and institutional barriers.

Positive environmental factors of water storage and transfer would include flood control and adequate water supply. The absence of each is a precursor to severe environmental impacts that also span from the ecological to the social. Each individual

water storage and transfer project must be analyzed, with and without the project, in site-specific terms and with accurate site-specific data to permit an estimation of impacts.

The largest legal barrier is water rights. In the western part of the United States, water rights as opposed to riparian rights dominate. A water right is solely a creation of law.[9] It is a set of relationships between a person who is said to own the water right and all other persons in the world, relative to a particular source of water. The establishment of water storage and transfer projects, in the West, involves the need to purchase rights to the water from its owner. Frequently, this is very difficult and expensive.

Based on recent Presidential and Congressional action on large-scale water projects, it is unlikely that any new large-scale storage and transfer projects will be initiated. Emphasis on solutions to local water supply problems is with regard to conservation and reuse. Conservation, primarily reducing losses through conveyance systems--seepage, infiltration, evaporation, etc., and improved management practices indicate savings commensurate with the capacity of some proposed projects and at a reduced cost.

Most storage and transfer projects built in the western part of the United States were originated for agricultural purposes, primarily for irrigated acreage. It has been shown that treated municipal sewage may be used for irrigation purposes.

Reuse of this resource is less costly than new transfer systems. Federal requirements for upgrading municipal effluents and for controlling industrial pollutants in municipal effluents makes reuse more viable.

Transportation of Icebergs

The concept of transporting ice from its place of origin to a distant location for use is not new. Such practice was done on a fairly regular basis along the coast of South America between 1890 and 1900.[12] Interest in iceberg towing operations was revived in 1960 and has intensified since the early 70's.[13,14] An appraisal was made of the existing and future water supply of suitable icebergs in terms of: the towing power required; the ice loss due to enroute melting; and the overall economic feasibility of towing icebergs from the south polar region.[15] Most published literature emphasizes, however, the necessity for pilot projects to verify assumptions and calculations; but, to date, no such demonstration projects have been initiated.

Tow testing of small-scale icebergs (16' x 4' x 1.6') was conducted from October 1978 to January 1979 under the auspices of the U.S. Navy Postgraduate School at Monterey, California. The project investigated gross regression rates of ice surfaces, wake temperatures, turbulent thermal boundry layer and shape changes over the melting period.[16]

The concept of towing tabular icebergs from Antarctica to the southern coasts of Australia and South America and the southwestern coast of Africa is both technically and economically

feasible.[15,17,18] The feasibility of transporting fresh water in the form of icebergs to the coasts of the United States is, however, doubtful. The availability of large pieces of tabular ice is almost exclusively limited to Antarctica. The distance between that region and, for example, the southern Pacific coast of the United States is 8,000 miles or more. Such a distance would require a transit time of 10 months or more, provided the towing vessel could average a one-knot towing rate during the entire trip and that the iceberg of towable size would not melt prior to arrival.[15,16]

The transport of icebergs from their source regions to a point where they could be processed for the extraction of fresh water would involve the following operations:[17]

- Location
- Selection
- Breakout
- Hook-up
- Transportation
- Termination

Satellite photographic techniques are available for use in locating and selecting tabular icebergs which have the shape and size to meet delivery criteria. Breakout of large tabular icebergs may not be necessary depending on the time of year (e.g., Antarctic summer) and the location of the glaciers relative to open water. There is very little information regarding the technique of breaking out an iceberg and considerable doubt exists that a breakout could be effected.[18]

Assuming that an iceberg of proper size and shape is found and is free to be moved, hook-up remains a problem. Two approaches to problem solution have been published:[18] One involves the sinking of deadman-type anchors beneath the surface of the iceberg; and the second envisions a bridle or net which would surround the entire iceberg. There is no indication in available literature that either of these proposed hook-up methods have been attempted, nor is there indication that the space and manpower requirements of these hook-up systems on the towing vessel has been investigated.

Problems mentioned in iceberg towing are summarized below:

- No unprotected iceberg would be likely to survive the ablation caused by a long trip to low latitudes. On shorter journeys, e.g., to Australia, unprotected tows may be possible
- Icebergs with a horizontal dimension exceeding about 2 km may well be prone to mechanical breakup by long wavelength swells. Thinning by ablation would aggravate this problem
- Stability considerations indicate that a 200 m thick iceberg must be at least 300 m wide. Cliff erosion and vertical thinning are additional factors to be considered in assessing long-term stability
- Anticipated problems dictate a very limited choice in the size of icebergs that would be suitable for towing .

An additional factor affecting operational feasibility is weather. On a short trip. e.g., to Australia (assuming a distance of 1,875 nautical miles at a speed in advance of one

knot, the trip would take approximately 75-80 days), the travel time is such that it would be unrealistic to assume calm, storm-free conditions during the journey even if conducted during the Antarctic summer season. Heavy weather conditions could significantly affect travel time; cause iceberg breakup; and/or result in loss of the entire tow.

Although tow vessel power requirements have been investigated,[15,18] no substantial analyses have been made of vessel configurations. Due to logistics considerations and the evolutions required in preparation for towing, the configuration of the tow vessel may require significant modification and/or new design to accommodate requirements for large fuel capacity, space for the storage of towing gear, and crew.[19]

There has not been any regular transport of ice from origin to user during the 20th Century. The rate of ice delivery, the size of icecakes and the sizes and characteristics of the towing ships which moved ice along the South American coast during the last decade of the 19th Century are not known.

Interest in the concept of transporting ice from south polar regions to arid regions to supplement fresh water supplies has increased since 1960. Since then, there have been a number of laboratory studies and published papers regarding feasibility including an identification of anticipated problems in terms of geophysical and engineering areas that require further investigation. Only limited testing (1978) with very small icecakes has been performed. No actual *in situ*, pilot demonstration

projects have been initiated. Available literature does not indicate any plans to conduct such demonstration projects. Further, most of the technical studies recommended by publications in 1973 have yet to be undertaken. Interest and study of conservation and reuse schemes, including the use of treated sewage effluent to extend available water supplies, seem more probable than iceberg towing.

WATER USE AND REUSE

Topics of investigation under this subject include: irrigation; industrial use of brackish water; water reuse and recycle; water conservation devices; liquid waste disposal; and solid waste disposal. General findings are as follows:

- Irrigation will continue to be the dominant use of ground water in the U.S. Adoption of recycling and reuse of treated sanitary wastewater for direct crop watering and for aquifer recharge is highly probable. Improved management practices and conservation are likely to be adopted over the next 20 years to extend available supplies

- No evidence exists that industry will depend on salt or brackish water for process and cooling requirements during the next 20 years

- Reuse and recycle of process and cooling waters will increase significantly over the next 20 years due to pollution legislation and economics

- Water conservation devices will not be widely adopted until their performance is improved and maintenance requirements have been decreased

- Federal legislation exists and state programs are being developed to control the release of liquid and solid wastes into navigable waters, including accidental discharges. This legislation will be implemented during this decade.

Irrigation

Irrigation in the United States began with the Indian settlements in the Southwest long before the first European colonists arrived. In later history, Spanish colonists expanded the cultivation of the Southwest by artificial application of water. As early as 1870, as many as 275,000 acres were irrigated. By 1889, irrigated agriculture had increased to include 3,631,381 acres. In 1935, the Hoover Dam made possible the cultivation of more than a million additional acres. By 1967, the Bureau of Reclamation had completed the construction of 252 storage dams, 126 diversion dams and 48 hydroelectric plants,[20] further extending the acreage opened up for cultivation and irrigation.

Irrigation of agricultural land is the most powerful method for increasing crop yields and reducing crop variability. Irrigated acreage has expanded with population to provide not only their food and fiber needs but also to make possible habitation of arid and desert areas. During the present century, the amount of irrigated acreage worldwide has increased exponentially, doubling every thirty years to an extent now comprising some 15 percent of the total cultivated area. Out of a total of 460 million acres of developed land in the United States, a 1974 survey estimated the total irrigated area to be 41,313,000 acres.[21]

Most irrigated lands in the United States are in the western region. In 1975, California accounted for 23 percent

of all irrigation water consumed. Large-scale irrigation projects are also located in the arid and semiarid regions of the plains and western mountain regions. Between 1975 and 2000, it is expected that about 56 million acres of irrigated land will be developed for agricultural use. A regional breakdown of present and forecast acreage is provided as Table 5-2. More than 1 million acres of land for future crop production may be taken from currently wet soils and other lands that require minor improvements.

Irrigation is an inherently consumptive use of water, and it is expected to continue as the dominant source of water consumption throughout the next 20 years. Irrigation water withdrawals totalled 159 billion gallons per day in 1975 with an associated consumptive use of 86.4 billion gallons per day.[22]

The future of agricultural demand for water depends upon a number of variables, including: food and fiber demand (domestic and export); federal policies adopted for control of farm production, resource and development, and environmental quality; the rate of technological advance; and the price of water for various users.

An evaluation of the nation's water supply situation for irrigation has generally indicated an overall positive outlook but with localized supply problems. It is likely that the U.S. agriculture will not be faced with overall, large-scale aggregate strains on food producing capacity and water supply

TABLE 5-2. Summary of Agricultural Lands, by WRC Regions, 1975, 1985, 2000

Region	Agricultural Land*	Crop Land			Irrigated Farm Land		
	1975	1975	1985	2000	1975	1985	2000
New England	3.7	2.8	2.7	2.6	0.1	0.1	0.1
Mid-Atlantic	16.6	11.7	11.6	11.2	0.3	0.4	0.5
South Atlantic-Gulf	40.6	25.3	25.7	27.5	2.0	2.6	3.0
Great Lakes	27.3	24.9	25.4	25.4	0.2	0.2	0.3
Ohio	46.9	32.9	33.0	33.0	0.1	0.1	0.1
Tennessee	8.0	4.4	4.4	4.4	0.1	0.1	0.1
Upper Mississippi	75.7	64.1	64.3	64.7	0.2	0.3	0.4
Lower Mississippi	30.3	20.4	21.9	22.5	2.0	2.5	2.9
Souris-Red-Rainy	24.2	20.8	20.9	20.9	0.1	0.1	0.3
Missouri	267.4	105.7	105.3	105.1	9.7	11.0	11.5
Arkansas-White-Red	111.0	44.5	44.6	45.1	4.8	5.4	5.5
Texas-Gulf	83.7	25.0	24.9	24.6	4.8	4.2	3.4
Rio Grande	66.1	2.9	2.8	2.8	2.0	1.9	1.9
Upper Colorado	37.3	2.0	2.1	2.1	1.4	1.5	1.6
Lower Colorado	53.7	1.5	1.4	1.4	1.3	1.2	1.1
Great Basin	117.6	2.6	2.8	2.8	1.7	1.5	1.6
Pacific Northwest	70.2	19.2	19.1	18.9	6.2	7.4	7.8
California	38.9	10.9	10.6	10.4	8.7	9.3	10.1
Alaska	238.2	0.1	0.1	0.1	0.1	0.1	0.1
Hawaii	1.0	0.3	0.3	0.3	0.1	0.1	0.2
Caribbean	1.4	0.5	0.5	0.4	0.1	0.1	0.1
Total--Regions 1-18	1066.5	421.3	423.6	425.3	45.3	49.6	52.2
Total--Regions 1-21	1307.1	422.2	424.4	426.1	45.5	49.8	52.4

*Agricultural land includes crop land, pasture, and range land. Other agricultural land, forest, and woodland are excluded.

needs until after the year 2000. However, there will be severe water problems in certain areas of the country prior to this time. The most arid areas of the West are presently subjected to occasional flooding while the humid areas of the East have experienced seasonal water shortages. Large population increases and industrial expansions are creating water shortages and pollution problems on both a local and a regional scale. The increasing usage of chemicals in agriculture has created pollution problems in some regions.

Approaches that can be taken for meeting localized demand for water include technological advances to improve efficiency in water use, development of practices and systems to maintain and improve the quality of water, additional control of streams and rivers to prevent flooding and provide for water storage, and water reuse practices.

Efficiency in irrigation is the delivery and application of only the amount of water needed to replenish soil moisture in the root zone of the crop and to satisfy any leaching requirement for salinity control. Improved irrigation-efficiency could be achieved in three broad areas: scheduling of water application; improvement of on-farm water handling methods; and improvement of project-wide water handling methods. It is estimated that the adoption of such technology and practice could save as much as 10 percent of the water currently consumed. Such water efficient irrigation systems as sprinkler or drip

system for certain crops could result in the reduction of water consumption by as much as 40 percent.[22]

Efficiency in management and use will extend the present supply of available water for irrigation. Methods are also being investigated to extend existing supplies or to establish new sources of supply. A method of emerging interest is the direct use of treated sewage effluent from municipal treatment facilities for crop irrigation and for recharge of ground water supplies. Recharge of ground water aquifers would supplement natural processes and also serve to extend or enhance present supplies. Desalination is a possible new source of supply for land areas proximate to the coasts.

Water reuse, including the direct application of treated municipal sewage, is a means for augmenting the supply of surface and ground waters. Localized limitations of present sources of water supply, increasing delivery costs for that supply and water pollution control requirements for high quality treated effluent have increased the national interest in water reuse and in wastewater reclamation. Several crops are currently being irrigated by municipal wastewater with excellent results.[23] In California, truck crops such as asparagus, beans, cucumbers, onions and tomatoes are sometimes irrigated with such effluents.

Ground water recharge by percolation or well injection using treated municipal wastewater is a method of interest for extending the use of ground water supplies. Ground water aquifer recharge with treated effluents has been shown to be an effective

method of recharge as well as a means of minimizing salt water intrusion. The use of treated effluent for recharge and hydrostatic head purposes is likely to increase greatly over the next 20 years. Such practices have been utilized in coastal areas threatened by intrusion and in the arid southwestern United States where ground water mining is now occurring.

Aquifer recharge using treated effluent may be accomplished by percolation or by well injection. Recharge by percolation has several advantages over recharge by well injection: standard quality effluent from secondary treatment facilities can be used successfully; capital costs and operation and maintenance requirements are minimal; and the soil provides a form of tertiary treatment. Currently only a small percentage of treated municipal wastewater is reused.

Projections for irrigation waters between 1975 and 2000 indicate an increase in withdrawals to 1985 with a slight decrease through 2000. During the same period of time, consumption is expected to remain constant. Constant consumption is inherent in agriculture, unless some form of capture of return flows is implemented. Such a capture and treatment system appears to be presently technologically and economically infeasible. Indeed the requirement of such systems for waste disposal sites, which involves much smaller land areas, has been cited as a major barrier to implementing waste disposal laws.

The estimated 40 to 50 percent savings in water realized by adopting efficiency management and new equipment (e.g., spray or drip irrigation) is already being investigated. Similarly, increased use of treated municipal effluent will probably occur. On a local basis, irrigation by wastewater, either partially or completely treated, will help to solve multiple problems of irrigation and waste disposal.

Industrial Use of Brackish Water

The use of brackish water by U. S. industry has not yet occurred. Israel appears to be the only country that has used brackish water for industrial purposes. The use of this water in Israeli industry during the past ten years is shown for the various categories of salinity in Table 5-3. The relatively large increase in use in 1970/71 is partly accounted for by the fact that Haifa Refineries Ltd. began to use treated sewage effluent in large quantities (450,000 cu. m) that year. Most of the brackish water is used in the mining and quarrying, chemical, and food industries.

TABLE 5-3 Water Use in Israeli Industry
(MCM/year)

Year	Total	400 ppm Cl	400-2000 ppm Cl	2000 ppm Cl
1963/64	57.3	37.3	15.1	4.9
1964/65	54.4	36.4	13.7	4.3
1965/66	59.1	37.8	15.9	5.4
1966/67	60.8	36.7	17.2	6.9
1967/68	66.0	40.3	14.4	11.3
1968/69	70.2	46.0	16.8	7.4
1969/70	75.9	50.0	16.1	9.8
1970/71	86.3	56.4	18.0	11.9

Three categories of brackish water are considered for possible use: less than 400 ppm Cl; between 400-200 ppm Cl; and greater than 2000 ppm Cl. Brackish water of the first two categories is considered of good quality and suitable for recirculation in operations such as cooling, washing and dilution in all branches of industry. Particular industries for such use are chemical, mining and quarrying industries. Brackish waters of the third category can be used in industry, but mainly on a once-through basis only, as, for instance, in open circuit cooling.[24] The permissible salinity level in recirculating cooling water is determined primarily by the compositon of materials from which the components of the cooling system are built (i.e., cooling tower, water pipes, heat exchange pipes, etc.); and by the type of water treatment used to prevent scale formation, corrosion and fouling, and to protect the internal structure of the cooling tower.

The use of brackish water must be supplemented by addition of fresh make-up water. The amount of make-up required increases nonlinearly with increase in salinity, according to the following rules of practice:

- To replace make-up water containing 200 ppm Cl by water of 400 ppm, a 12.5 percent increase in make-up is required,
- To replace make-up water containing 200 ppm Cl by water of 1000 ppm, an 80 percent increase in make-up is required,
- To replace make-up water containing 200 ppm Cl by water of 1,500 ppm, the make-up required increases by a factor of 3.6.

Water Reuse and Recycle

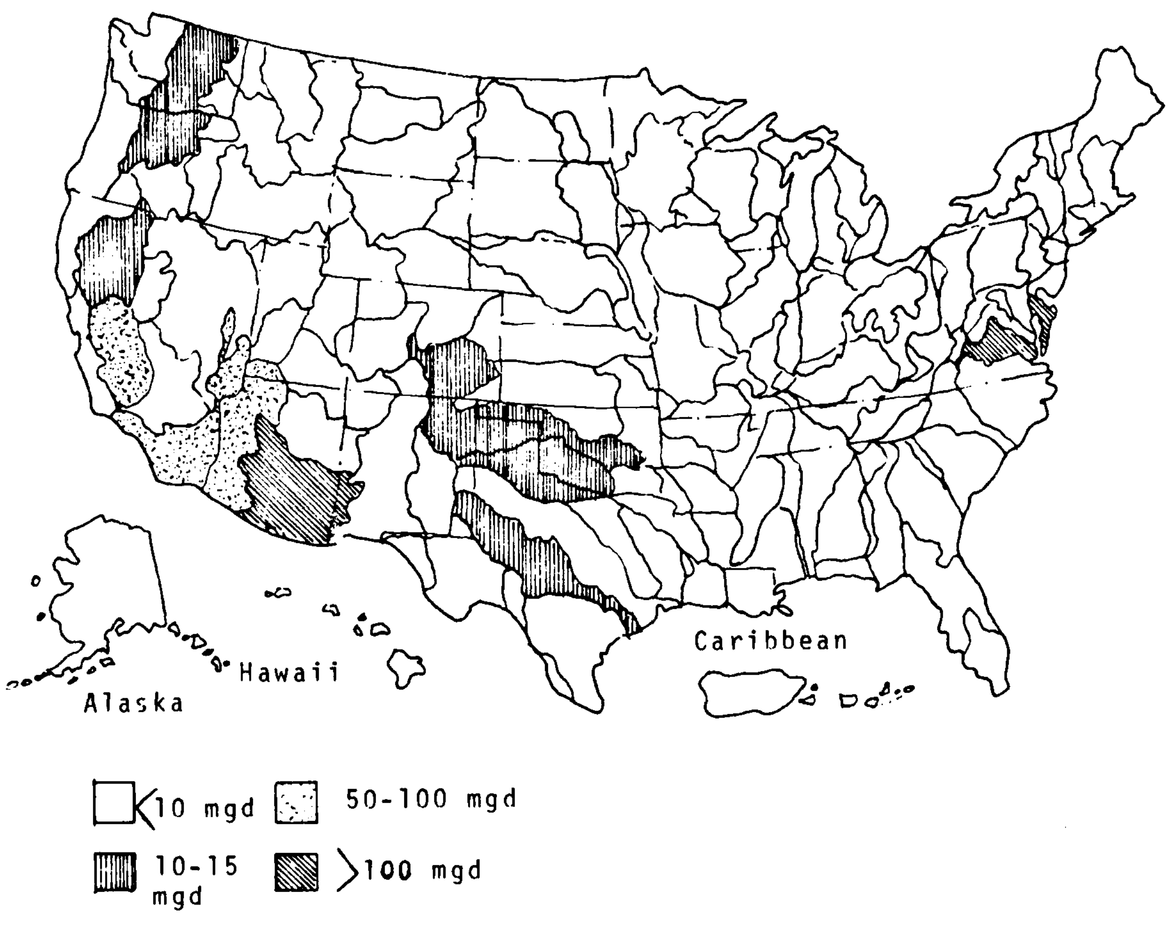
Reuse of water is an ancient concept. Sewage was used for irrigation in Athens. It was also widely used in Germany beginning in the 17th Century and in arid portions of this country during the last century. Problems of increasing population, industrialization and urbanization resulted in lengthy discussion of reuse and conservation at the historic U.S. Governors Conference held in 1908 in Washington, D.C.

Sewage, then later (1930) treated water, has been used for irrigation in Golden Gate Park in San Francisco since the park's inception. Grand Canyon Village has reused water for irrigation for 50 years. Bethlehem Steel Company at Sparrows Point, Maryland, has, for 50 years, used secondary treatment water from the City of Baltimore for cooling. A multi-purpose (irrigation/industrial) reuse project in Lubbock, Texas has been operating since 1938. The El Paso Products Company in Odessa, Texas has been using secondary effluent for both cooling and boiler makeup for more than 20 years. Amarillo, Texas, Burbank, California and Colorado Springs, Colorado are other locations where industrial water reuse has been in operation for 10 to 20 years.[25]

At present, there are about 535 existing water reuse projects in the continental United States, Hawaii and the Virgin Islands operating at a total (1975 estimate) reuse rate of 678 million gallons a day (MGD). Figure 5-2 shows existing water reuse projects.

FIGURE 5-2

Existing Water Reuse Projects



As of 1975, about two-thirds of these projects involved small irrigation disposal operations. Until quite recently, the typical municipal reuse project has involved the delivery of primary or secondary effluent to a single user for small-scale irrigation of pastureland, forage crops, or nonfood crops such as cotton.[25]

The reuse picture is changing. Analysis of data contained in a 1975 report to EPA[25] shows a definite improvement in the quality of reclaimed water delivered to users in the more recent projects. Reuse projects that had been started before 1967 were apt as not to "violate" what are now the secondary treatment criteria for biochemical oxygen demand (BOD) and suspended solids (SS); but some 80 percent of the projects initiated after 1967 satisfied these criteria.[25] Additionally, there is a trend toward larger capacity reuse and recycle projects. The technical and operational feasibility of water reuse/recycling has been proven.

Reuses requiring waters of secondary quality are considered economically feasible. These include agricultural irrigation, livestock and wildlife watering, once-through cooling, and process water for primary metal industries. Landscape and urban irrigation using filtered secondary effluents is feasible, as is the use of this effluent for enhanced oil recovery.[26]

Domestic reuse is considered economically feasible in certain areas of the country, based on existing and projected costs. Domestic use has been proven to be practical in Windhoek, South Africa, and in the Dan region of Israel, and is proposed for the Denver area. Pilot and full-scale projects for domestic use are currently being tested and evaluated at Washington, D. C., the Occoquan Reservoir, Virginia, and in Orange and Truckee Counties in California. Groundwater recharge to potable aquifers by injection and percolation basins is operational in California.[26]

Uses that are not economically feasible include warm and cold water fisheries and primary and secondary recreation. The level of treatment required for these uses is high and the treatment processes costly. The food industry also presently represents poor economical feasibility with regard to reuse.[26]

Barriers to reuse and recycle tend to vary in severity in inverse ratio to the adequacy of the fresh water supply. The following represent the kinds of considerations, which vary with location and which could act as a barrier:

- Where water is an inexpensive commodity and the supply of that fresh water is plentiful, the reuse of municipal effluents or extensive internal recycling is not economically advantageous.

- Where wastewater treatment requirements are stringent, the marginal cost involved in bringing effluent up to industrial quality requirements may be relatively small. The burden of the majority of the treatment cost is on those who discharge wastewater, so that the production and delivery of reclaimed water to industrial users are economically favorable.

- Public support in terms of grants for construction or in terms of increased potable water price is often needed to make a reclaimed water distribution system economically viable. Historically, each new source of water costs more than the previous source, and the new higher costs are simply averaged with the earlier lower costs. When dealing with a shortage of water, the issue is not necessarily the cost of reclaimed water compared with potable water price, but whether reclaimed wastewater can be afforded to increase total water supply. The positive aspects of having more water must be weighed against the negative aspects of higher costs or the possible alternatives of water rationing or elimination of lower priority uses.

- A reclaimed water distribution project must maintain the existing water market chain from supplier through wholesaler to retailer and user of reclaimed water. Any attempt to bypass one of these major links would cause disruptions and misallocations of costs and opposition to a project.

- More stringent discharge requirements for industry will increase the amount of internal recycling and reduce the opportunity for distribution of reclaimed municipal effluent to users.

- One economic factor is the cost to meet discharge requirements, i.e., sewer services charges. Internal recycling becomes cost effective when discharge requirements reach some critical level,

> provided that treatment costs have not increased to the point where industry is out of business. With increasingly stringent discharge requirements, the volume of water used generally increases, thereby diluting the concentration of pollutants below discharge levels. However, once discharge requirements reach some point, the effluent water becomes too good to throw away and recycling becomes cost effective.[27]

A study completed last year for the OWRT projected that reuse would undergo a fourfold increase by the year 2000, growing from 0.2 percent of freshwater withdrawals in 1975 to 1.7 percent in 2000. The 4.8 billion gallons per day (BGD) reused would be largely dedicated to agricultural irrigation in the California, Missouri, and Pacific Northwest basins. The numbers alone would appear to indicate a relatively small role for municipal wastewater reuse, particularly when compared to the tremendous water conservation that will be realized through improved industrial recycling techniques (by 2000, some 866 BGD will be recycled in the steam electric, manufacturing, and minerals industries, according to the OWRT study).[25]

Water Conservation Devices

Interest in water conservation is relatively new. The realities of shortages of water supply coupled with increased demand and increased economics have produced an awareness that, like energy, conservation is desirable.

Recent studies have documented available water conservation devices for domestic use. Most of these devices

are designed to decrease the volume of water discharged by home devices such as toilet fixtures, showers, washing machines, dishwashers, etc. The results of two studies are summarized in Tables 5-4 and 5-5 (references 28 and 29, respectively).

As shown in the tables, the results of the use of various devices is sporadic and variable. One reason cited for such results is that no consistent experimental design or evaluation of data has been performed.[30] Rather each installation and follow-up was for different applications (although similar) with no common basis provided. For example, reductions in household water use range from 16 percent to an actual increase. The most consistent conclusion identified is that although each device could reduce water consumption, the critical variable in the extent of savings achieved was in follow-up maintenance and adjustments. In other words, the devices are not as maintenance-free as the appliances/ fixtures on which they are installed.

Limited experiments have been conducted in commercial use. Flush valve and vacuum toilet flushing have been successfully used in hotels, office buildings and housing in Europe.[31] Similarly, the use of low-flow showerheads in dormitory usage produced reductions in water use of from 37 percent to 62 percent.[32]

Conservation devices for industry are less defined

TABLE 5-4. Water Savings vs. Cost in Dollars for Plumbing Devices

Hardware Devices	Water Savings gpcd+	Water Savings gpd*	New Construction Estimated Cost Installed Matl.	New Construction Estimated Cost Installed Cost	Old Construction Estimated Cost Installed Matl.	Old Construction Estimated Cost Installed Cost
1-Limiting Flow Valves for Shower	6.0	24	15	15	35	50
2-Limiting Flow Valves for Lavatory	0.5	2	25	25	45	68
3-Limiting Flow Valves for Kitchen Sink	0.5	2	25	25	45	68
4-Aerator for Lavatory and Kitchen Sink	0.5	2	2	2	2	2
5-Thermostatic Mixing Valve	2.0	8	80	90	80	100
6-Batch-type Flush Valve (1) for Water Closet	7.5	30	25	40	75	105
7-Batch-type Valves (2) in Dual Cycle	15.5	62	55	70	120	158
8-Urinal with Batch-type Flush Valve	7.0	28	125	148	150	175
9-Shallow Trap Water Closet	7.5	30	20	20	80	110
10-Dual Cycle Water Closet	17.5	70	10	10	100	130
11-Vacuum Flush Toilet (100 Homes)	22.5	90	--	(110)**	--	295
12-Vacuum Flush Toilet (Single Homes)	22.5	90	--	115	--	1520
13-Washing Machine with Level Control	1.2	5	35	35	35	35

+ gal/capita (gal/person/day)
* four-member household
** negative cost, i.e., cost reduction

TABLE 5-5. Water Savings Versus Cost for Household Devices

Household Devices	Water Savings gpcpd	Reduction in Household Water Use (%)[a]	"Approx." Additional Cost[b]	Remarks
Flow Control Devices--Faucets:				
Kitchen Sink	0.5	0.8%	65¢-$5 ea[c]	Installed on kitchen sink hot and cold water 2-1/2 gpm flow rate
Lavatory	0.5	0.8%	65¢-$5 ea[c]	Installed on bathroom lavatory hot and cold water 2-1/2 gpm flow rate
Aerators	0.5	8.8%	$1 ea	Installed on kitchen sink and lavatory faucets
Insulation of Hot Water Pipes	2.0	3.0%	50¢/ft.	Slit foam tubing
Flow Control Devices--Showers:				
Flow Control Head or "In-Line" Fitting	7.5	12.0%	65¢-to $5 ea[c]	3 gpm flow rate
Thermostatic Mixing Valve	2.0	3.0%	$24 ea	Installed on kitchen sink and shower/bath
Reduced Water Toilet Devices:				
Shallow Trap Toilets	7.5	12.0%	$13 ea	Based on water requirement of 3-1/2 gals. per flush
Flush Valve Toilets	7.5	12.0%	-	
Toilet Dam	5.0	8.0%	$6 ea	Savings higher with some toilets
Displacemt. Bottles	2.5	4.0%	40¢ ea	2 1-qt. bottles displacing 1/2 gals. per flush
Specialty Systems:				
Minuse Shower	14.0	22.0%	-	
Vacuum Flush Toilet	22.5	35.0%	-	
Compressed Air Toilet	25.0	39.0%	-	

a--Household water use taken as 64 gpcpd (excludes outside irrigation).
b--Matls. only and based on cost over and above "normal" practice. Prices are "ball park" ests.
c--Price varies depending on materials. Low value is for plastic insert. High value is for chrome-plated brass fittings.

in the literature. The major thrust in agriculture, industry and steam generation is recycling and reuse of withdrawn water or use of treated municipal sewage (primarily for agriculture). For steam generation water conservation devices for cooling are dry cooling towers and fin-fan cooling. These devices are expensive, primarily in terms of the increased energy consumption required to achieve water conservation.

The primary barriers toward the adoption of water conservation devices in households and in commercial use are the variability in performance (e.g., water saved) and the requirement of periodic maintenance and adjustment. For example, the tables presented above indicated a possible reduction in water consumption varying from 12 to 20 percent for showerhead devices; however, a recent report from the Comptroller General indicates that the actual reduction may have been as low as one percent.[32] This contradictory or at least highly variable performance could undermine consumer confidence in purchasing and using such devices.

Requirements for maintenance and adjustments are a barrier. The house appliances for which these devices are to be used are considered reliable and essentially maintenance free. Indeed, replacement is more common than maintenance. Devices requiring professional installation plus periodic adjustments (i.e., a service contract) would not receive high demand.

Other barriers cited include: the lack of verifiable data on device effectiveness, a lack of reliable or unbiased data on their actual performance, and a general lack of availability of these devices in customary plumbing fixture outlets.[33] These problems coupled with the lack of substantive data on cost-savings indicate that the development of water-reducing technology is still in an early stage.

The adoption of water conservation devices by other than domestic or commercial sectors is doubtful. Devices for agricultural, power generation and industrial use are generally lacking. Emphasis in these sectors is in the reuse or recycle of process waters, including the reuse of treated municipal wastewater. At the residential level, recycle or reuse systems are extremely rare; no complete systems are as yet commercially available.[34]

The adoption of water conservation devices for residential use will require technological advances to decrease present maintenance and adjustment requirements and a coordinated public relations campaign. The use of devices to control usage is not as effective as water metering. Reductions in usage of from 27 to 50 percent have been reported for metered areas versus flat-rate areas. Outdoor use of water, primarily lawn and garden sprinkling plus car washing, decreases in proportion with cost. A coordinated public relations campaign could provide factual information on available devices including economics and effective conservation.

Public relations campaigns have been successfully used to achieve water conservation goals through decreased usage and not necessarily conservation device utilization. Campaigns comprising distribution of handbooks, workshops, slide programs, product data on devices, television and radio advertisements, bumper stickers, plumbing code changes, and distribution of plastic bottles for reduced toilet flushes (tank volume) and of showerhead flow reducers was tried by the Washington Suburban Sanitary District and achieved reductions of approximately 10 percent.

Liquid Waste Disposal

Wastes or by-products of man and industry are gaseous, liquid and solid. Liquid wastes resulting from water flowing over land (non-point source) and directly from domestic and industrial activities are discussed in this section. Solid wastes are discussed in a subsequent section. Gaseous wastes are not discussed.

Non-point pollution originates from farming; lumbering; pesticides and fertilizers applied to crops and lawns; disposal of waters on or under the ground; construction; and mining. Erosion is a major cause of non-point pollution. Sediments from non-point sources are estimated to be 360 times the quantities discharged from municipal and industrial point sources. Oxygen demand from these sources is estimated to be 6 times that of municipal and industrial point sources.

Non-point sources of water pollution currently produce more than half of the pollutants entering the Nation's waterways.[35] They are especially difficult to control. According to the CEQ and the EPA, control of non-point sources can be achieved, but progress to date has had limited success and high cost.

Seventy-two percent of the river basins in the United States are affected by industrial pollution with the Northeast and Great Lakes regions most affected. Industrial pollution includes oxygen depletion, excessive suspended material, oil and grease, heavy metals, toxic substances, thermal effects and pH problems.

Pollution controls for industry are regulatory, being specified as effluent limitations for industry achievement. The Federal Water Pollution Control Act Amendments of 1972 directed EPA to establish effluent limitations and defined technology for achieving those limitations for discharges. The Clean Water Act modified both limitations and compliance schedules. Accordingly, EPA has defined pollutants as "conventional", "non-conventional" and "toxic". Technology-based standards for each category and pollutant are to be developed. A "technology based" standard means that control technology (processes and equipment) availability and cost have been accounted for in setting the standard. The process of setting effluent limitations, by category of pollutant, involves the collection and analysis of data on pollutant

sources and composition, control technologies and their economics, and on economic impacts.

Industries that do not discharge directly to navigable waters, discharge to municipal treatment plants. EPA has estimated that up to 25 percent of all wastes received by municipal sewage treatment plants is industrial.[36] Industrial waste can disrupt or kill biological municipal treatment processes, pass through a process unaffected or create sludge disposal problems. To address these problems, EPA has developed a national pretreatment strategy and obtained regulatory authority to establish national pretreatment standards. The standards provide specific criteria for the discharge to municipal facilities by specific industry. Further, an enforcement program for these pretreatment standards will be required as part of the NPDES permit for the municipal facility receiving industry wastewater.

July 1, 1977 was the deadline for industrial discharges compliance with effluent limitations based on Best Practicable Control Technology (BPT, PL 92-500). Approximately 81 percent of the 3,795 major industrial dischargers complied; 724 did not. By February 1980, the number of industries in noncompliance was decreased to 627. The worst 300 offenders have been targeted for civil and criminal enforcement actions.

Eighty-nine percent of the river basins in the United States have adverse effects due to municipal treatment

facilities. Most of these problems are due to facility overloads or inadequate treatment. Pollutants most often encountered include fecal coliform bacteria, oxygen demanding material, phosphorus and nitrogen. Municipal discharges can also include excessive suspended and dissolved solids, heavy metals and toxic organic compounds.

Combined sewer systems can severely degrade water quality. Especially in older cities of the Great Lakes and Northeast regions, sewer systems handle both domestic and storm wastewater (including industrial). During times of rainfall, the combined wastewater is dumped directly into receiving waters after, perhaps, disinfection; municipal treatment facilities do not have the capacity to treat such large volumes, and it may be uneconomical to build and operate facilities that would be utilized at capacity only once in twenty-five years.

July 1, 1977 was the Congressional deadline for municipal facilities to meet secondary treatment criteria. Fifty-eight percent of all major municipal discharges did not meet the deadline. Federal financial assistance will be provided to municipalities to help achieve secondary treatment. Federal grants coupled with NPDES permit requirements will control municipal discharges. Further, EPA has reached an agreement with the Army Corps of Engineers to have the Corps assist in construction supervision of facilities developed.

Only sixty-six percent of the major discharges by Federal facilities achieved compliance with secondary treatment

requirements by the July 1, 1977 deadline. The Administration has provided $484 million to assist in achieving compliance; plus an Executive Order requiring that Federal installations meet applicable Federal, state and local environmental requirements.

A recent estimate[37] of the total input of petroleum hydrocarbons to the oceans is approximately 6 million tons annually. About 2 million tons of this total is attributable to transportation of petroleum by the sea. This contribution has been predicted to increase to 6 million tons by 1980.[38] The remainder is defined by: offshore oil production (.08); coastal oil refineries (.2); industrial waste (.3); municipal wastes (.3); urban runoff (.3); river runoff (1.6); natural seepage (.6); and atmospheric depositions (.6). The numbers in parenthesis are the annual estimated quantity in millions of metric tons. Regardless of the sources, the volume is large and is expected to increase at a 4 percent annual rate.[39]

At the International Conference on Tanker Safety and Pollution Prevention in February 1978, new standards for tanker design and operating procedures were adopted by members. The U. S. Coast Guard has announced a schedule for implementing these new international standards for new ships by 1979 and by 1981 to 1985 for existing ships.[40]

The new standards establish the necessity of segregated ballast and crude oil washing to prevent operational discharges from tankers. Segregated ballast eliminates oil discharges in

that ballast water is carried in separate tanks. Combined, these procedures are expected to eliminate the 1.3 million metric tons per year of hydrocarbon discharges from tankers. Other requirements from the conference include: dual radars and redundant steering controls on new and existing tankers; a recommendation that automatic collision avoidance aids be made mandatory; and improved inspection and certification standards.

The United States has not yet ratified the 1978 IMCO Conventions and Amendments. The U. S. Coast Guard is implementing similar provisions under the Ports and Waterways Act of 1972. Implementation involves boarding and examining each tanker entering U. S. waters at least once a year, noting deficiencies in a permanent record for each vessel. The record also includes accidents and pollution incidents.

Technology is not considered a barrier to pollution control. Prime barriers appear to be financial and institutional. Financial problems were encountered when municipal construction grant funds were impounded. The Clean Water Act extended the time-frame for obtaining such funding and increased the level of funding available. Solving the financial problems through federal funding induces institutional problems. For example, 39 states are authorized by the EPA to issue and enforce the NPDES program. This authority requires additional

staffing to administer permits and to perform the necessary monitoring required for enforcement. The acquisition and training of qualified technical staff remains a problem.

Enforcement of industry standards is a problem. EPA and the States have few resources to devote to industry enforcement. EPA and the States monitor primarily by requiring dischargers to sample effluent and report the results; regular inspections, at least of major dischargers, supplement this self-monitoring program. A report several years ago for the National Commission on Water Quality concluded that self-monitoring reports were unusable. A 1978 report by EPA confirms that the problem remains a serious one; 99 percent of 106 sources whose self-monitoring programs were analysed had deficiencies which could result in unreliable results. The deficiencies included improper flow monitoring, poor sampling techniques, and inadequate quality control in analysis. Inspection programs are apparently not improving industrial monitoring.

Institutional and financial problems dominate for the control of non-point and point sources of pollution. For example, the slow progress of the Section 208 program continues. The program has been difficult to implement because of funding impoundments, lack of data on non-point source pollution, and the slow development of economical control techniques. The dominant problem appears to be an institutional one, however.

Solutions to complex local and regional water quality management problems will ultimately be devised locally and regionally. Yet the incentives for local governments to develop and implement effective water quality management programs are limited and often are overshadowed by the availability of federal construction grants and statutory compliance deadlines for point sources.

Additional concern is growing that small towns may not be able to afford the operating costs of facilities being constructed with federal grants. An EPA survey of 258 facility plans for communities with populations under 50,000 revealed that the total costs of the planned systems would exceed $100 per year for homeowners in 40 percent of the towns and over $200 per year for homeowners in 10 percent of the towns. For residents of communities with fewer than 10,000 people, projected annual costs approach $300 and sometimes more per household. The problem is made more acute by the fact that many small town homeowners have incomes well below the national median. The changes in the 1977 Amendments and in EPA policy discussed earlier encourage facility planners to consider more cost-effective alternatives.

A related problem is the availability of trained people, or of programs to effectively train people to operate and maintain municipal facilities. EPA surveys of operating treatment plants conducted in 1976 and 1977 reveal serious problems of operation and maintenance. Of the plants in the

sample with adequate operating data, less than one-half were achieving design performance in removing suspended solids. Fifty-five percent were meeting design criteria in BOD removal. Poor O&M has proved to be a stubborn problem. Surveys have shown no substantial improvement in performance efficiency of waste water treatment facilities over the past several years. A survey of 30 treatment plants showed that poor understanding by operators of waste water treatment concepts and improper application of these principles to plant operations were the two most frequent factors contributing to poor plant performance.

The adoption of pollution controls to achieve legislative requirements is a certainty. Standards and limitations reflect controls available. Court cases involving civil liabilities and consent decrees ensure adoption.

Solid Waste Disposal

Traditionally, solid wastes have been disposed on land. Earliest wastes were associated with human sewage. For example, in England, the first Royal Commission on Sewage Disposal (1857-1865) concluded that "The right way to dispose of town sewage is to apply it continuously to land".[41] Sewage treatment plants in England are called sewage farms.

The practice of disposal on land continued (with some disposal into the oceans) through the mid 1960's. Even today 50 to 75 percent of all solid wastes are disposed on land, either in sanitary landfills, land spreading, or "convenient

areas". Prior to the mid 1960's, responsibility for regulating waste disposal was primarily a state and local function. Local and state regulations were prompted due to concern over the public health aspects of waste. As the level of public health increased, most known infectious diseases were brought under control and little attention was then given to solid waste management.

During the 1960's, awareness of our environment spurred interest in controlling pollution. In 1965, Congress enacted the Solid Waste Disposal Act. This legislation established state and local planning for waste management. Awareness of waste as a possible resource for recycling or for energy production led Congress to enact the Resource Recovery Act in 1970. This law established research and demonstration grants for state and local disposal assessments. In 1976 Congress enacted the Resource Conservation and Recovery Act. This far-reaching legislation will, through regulations, establish and enforce a cradle-to-grave management/responsibility for solid and hazardous waste disposal. The Act prohibits the open dumping of solid wastes and specifies requirements with which sanitary landfills must comply in order to be operated.

Prior to 1960, some solid wastes were disposed by incineration, with residue or ash deposits disposed in landfills. Other solid wastes were discharged directly to waterways including the oceans. The Clean Air Act of 1970 effectively ended

incineration practices. The Federal Water Pollution Control Act Amendments of 1972 ended indiscriminate dumping of wastes into waterways. The Clean Water Act Amendments of 1975, to the 1972 Act, plus further modifications by Congress in 1977 extended jurisdiction over waste disposal in waterways to include toxic and hazardous substances.

Today, the Clean Water Act, the Clean Air Act, the Resource Conservation and Recovery Act, together with the Safe Drinking Water Act, the Underground Injection Control Act, and the Toxic Substances Control Act all govern waste disposal. Proposed regulations to each Act, plus the EPA proposed consolidated permit process[42] will, when promulgated, provide for regulation of waste disposal from product conception through waste generation and disposal, including liability and responsibility to the producer, for all effects that may occur from that product over all time.

Solid waste is produced by industry, residential and commercial sources and wastewater treatment. Industry wastes generated in 1977 were approximately 344 million metric tons; increasing at a rate of 3 percent per year. Wastes generated by residential and commercial sources in 1977 were approximately 130 million metric tons; also increasing at a rate over 3 percent per year. Sludges from wastewater treatment comprise approximately 5 million metric tons per year in 1977. This quantity is expected to double by 1985 due to upgrading of

municipal wastewater treatment facilities to comply with federal guidelines and timetables. These data are summarized in Table 5-6.

TABLE 5-6: Summary of Solid Waste Quantities (Millions of Metric Tons--Dry)

Source	1977	1985
Industry	344*	434
Residential & Commercial	130	180
Sludges	5	10
Total	479	624

*10-15 percent of this volume may be classified as hazardous.

A report by EPA in 1977 identified over 20,000 general sites for refuse disposal, 23,000 sludge disposal sites and more than 100,000 surface impoundments for industrial wastes.[44] In the past few years numerous instances of degradation of surface and ground waters as a direct result of waste disposal have been documented. For example, 43 of 50 sites sampled by EPA in 1977 showed migration of heavy metals and/or organic compounds into groundwater.[45] At 26 sites, water from monitoring wells exceeded EPA limits for drinking water.

The feasibility of continuing standard practice of waste disposal is nonexistent. The practices of open dumping,

open burning and incineration, indiscriminate discarding into oceans and waterways have all been prohibited or severely restricted by federal law and by state programs. Disposal into landfills has been constrained: in many urban areas, sufficient space does not exist; new design criteria for landfills obviate the expansion of existing sites; and public attitudes regarding "other people's" waste makes waste transfer difficult.

Considerable efforts today are being directed to identify environmentally acceptable ways to dispose of wastes. Awareness of the fragile nature of U. S. energy supplies and other resources has spurred interest in resource recovery, including energy production and minerals/metals recycling. Public relation campaigns, and in several communities, local ordinances, have achieved a degree of recycling through cash deposits for "returnable" items or through making available convenient locations for depositing segregated waste (e.g., bottles, cans, and newsprint). The rate of resource recovery is now about 7 percent. It has been estimated that this amount could be tripled through the source separation mentioned above.[46]

Solid wastes used to be dumped in the oceans. The U. S. Coast Guard has responsibility for enforcement and monitoring of ocean dumping. The Marine Protection, Research, and Sanctuaries Act prohibits the EPA from issuing permits for the dumping of sewage sludge into ocean waters after 1981. The U. S.

Coast Guard is given responsibility under the Act to ensure that ocean dumping occurs under a valid permit and at the location and in the manner specified by the permit. In 1977 this enforcement involved reporting of 35 cases involving 226 alleged violations of dumping permits, which comprised 126 dumpings at an improper disposal rate and 77 for failure to provide proper notification. Also during this time, ocean dumping dropped 12 percent from 1976 levels (excluding dredged material). Most material dumped was sewage sludge (70 percent). Industrial waste dumping decreased by over 65 percent. Almost all ocean dumping has been phased out of the Gulf of Mexico and waste disposal in ocean waters of the North Atlantic (Northeast and Mid-Atlantic) and Pacific (Northwest) is being phased out.

West Coast municipalities have, however, argued that ocean disposal of sewage sludge is a viable alternative, pointing out that such wastes are rapidly aerated and dispersed by strong currents and tidal action. EPA has established a modified permit program wherein both the level of treatment and sludge disposal into deep ocean waters may be negotiated. The results of such negotiations could be a five-year permit available only to existing dischargers.

This program might require U.S. Coast Guard permit

enforcement in collaboration with the U.S. Environmental Protection Agency, and perhaps with the cooperation of industry. The Coast Guard can take direct action in matters of international or interstate concern that are beyond the capabilities of the other involved agencies.

Implementation of such actions could involve some organizational elements of the Coast Guard and require close coordination with other governmental agencies, industries, and municipalities involved, and awareness of and adherence to related environmental regulations. Related operations such as surveillance detection, and response, could affect the nature and development of the Coast Guard's platform, manpower, and training requirements.

The barriers to waste disposal are environmental, economic, financial, technological and institutional. Environmental barriers span attitudes through impacts. Public attitudes regarding waste disposal are well known. The visibility of a landfill site coupled with vehicular traffic and noise all combine to make siting difficult. Impacts to waters, including contamination of drinking water supplies, from improperly disposed wastes are the prime potential behind recent legislation. Compliance with all governing laws and regulations, together

with the public hearing process will make waste disposal as environmentally compatible as practicable, but at a much higher cost than previously paid.

The costs of compliance with new regulations are unknown. Traditionally, waste disposal has involved collection, transport and disposal charges. Collection and transport has been by private or public personnel with costs to homeowners or industry governed by authority granted by local government. Disposal costs are assessed to users of the disposal facility. These costs are to cover the capital investment required to establish the disposal facility plus O&M. These costs will certainly increase to cover the design and operating features required by the Resource Conservation and Recovery Act.

Energy or resource recovery from wastes is not yet cost effective. These forms of disposal require the collection and transport costs of landfill disposal. Additional costs include waste processing for recovery. Processing can include mechanical classification and separation, shredding or mixing. Frequently, the processing costs exceed the costs of collection and transport. Capital costs for large-scale recoveries have been higher than landfills. The new requirements for the siting,

design, operation and closure of landfills will make recovery equipment more attractive.

A technological problem common to all recovery options is waste processing. Equipment to dry, shred or otherwise process waste for recovery is either lacking or limited. For example, shredders used for domestic waste will not accommodate waste tires. A major technology problem is that no landfills consistent with proposed EPA criteria have been constructed. Large-scale technology for leachate capture and treatment must be developed. Monitoring equipment for on-line measurements or for many organic compounds is limited.

Institutional barriers focus on the dilemma of (1) local efforts to ban the disposal of wastes within municipal borders and (2) the pressure on states to open up new landfill sites. Waste disposal began as a local problem which has spread through state and federal legislation. Federal regulations place requirements on states in order to receive funding (e.g., permit authority). Numerous states have enacted programs for granting permits for an applicant to build and operate a landfill in a municipality. The municipality may through zoning or local permits try to deny the project. Typically, the state permit program will preempt local control. It has been suggested that these battles between state and local control will escalate over the next several years.

Proposed regulations to various parts of the Resource Conservation and Recovery Act are, by court order, to be effective in the spring of 1980. Changing economics associated with energy and mineral resources will, with federal assistance, spur research, development and demonstration in these areas. EPA and DOE grants are already in progress. Present planning for municipal wastewater treatment facilities includes requirements for investigating sludge processing and disposal.

The largest source of solid waste is industry (over 70 percent--see Table 4-6). Literature regarding industry advancements in waste disposal is sparse. A measure of industry reaction is found in the fact that EPA regulations to RCRA, proposed in 1977 and 1978, have yet to be promulgated. Industry comments to the proposed regulations are being factored into EPA regulations.

The annual increases in waste generatedcoupled with the rising costs of land for disposal sites, and with new design and operating requirements, will change current patterns of disposal. A precise schedule for this change is unknown. Emphasis on pollution controls, including the schedule for implementation of more stringent water quality requirements by 1984, and toxic substances by that same year, will drive changes in waste disposal.

The limited number of facilities for processing or recovering waste will limit options. The financial barriers

of capitalization and markets will have to be overcome, perhaps through a federal program of incentives and guarantees. Pollution control legislation and energy requirements will continue over the next 10 years to produce such changes. Further advancements in energy recovery seem assured, due to the existing DOE loan guarantee program and to the proposed EPA grants to cities for planning and development.

The emphasis in waste disposal will shift, in the next several years, from the federal level to the state level. In this time, federal criteria and guidelines for local programs will be completed, and sufficient data will have been assembled to permit local problem solutions.

POWER GENERATION

Power generation was investigated in terms of power plants and hydropower. Power plants included conventional fossil plants as well as nuclear and alternate sources. General findings are as follows:

- The demand for electrical energy increases while debates over sources of energy to produce electricity continue. Synthetic fuels will increase water demand problems. Demonstration scale OTEC plants are probable. Federal directives and incentives will be structured to spur commercialization of synthetic fuels and to develop alternate energy sources

- The increasing use of agriculture as a "weapon" in the energy area cannot be denied. Crop productions are stabilizing. Prairie farmland is being "lost" to urban development. Energy production competes with agriculture for available water in the west

- Hydroelectric generation probably will not expand much beyond present capacities unless a major shift occurs in U.S. energy policy. Studies to be completed in 1981 could influence national policy in this area.

<u>Power Plants</u>

Over the past 25 years, electrical energy production has increased at an annual rate of 7 percent. The only exception to this growth rate was a period of lower growth during the energy crisis and economic recession of 1973 which continued through 1975. During this period, the growth rate in electricity demand ranged from less than 1 percent to almost 2 percent. By 1976, the rate of growth in energy consumption increased to 6.2 percent. Precise trends cannot presently be determined. Additional time is needed to see a definite trend as well as to study the impact of a national energy plan via voluntary and compulsory conservation measures.

Table 5-7 provides an estimate of future demand and supply of energy and electric generating requirements, by fuel source. Table 5-8 is a scenario of electrical energy demand, by sector, to the year 1995. Both tables indicate increasing demand.

The degree to which future electrification in the industrial, commercial, residential and transportation sectors will reduce demand for petroleum products is of national concern. The electrification question may require stronger federal emphasis on expanding coal and nuclear energy programs.

TABLE 5-7: Estimates of Total Energy Consumption and Electric Power Generation by Source of Fuel, 1975,1985, 2000

Type of Fuel Used	Gross Energy Consumption						Electric Power Generation					
	1975		1985		2000		1975		1985		2000	
	Quads	Per-cent	Quads	Per-cent	Quads	Per-cent	1000 gwh	Per-cent	1000 gwh	Per-cent	1000 gwh	Per-cent
Fossil	66.2	92	87.0	85	105.6	65	1,422	76	2,143	56	2,911	32
Nuclear	1.8	3	11.8	11	46.1	28	171	9	1,456	38	5,865	65
Hydro	3.3	5	3.3	3	4.3	3	281	15	261	6	298	3
Other	.3	1	1.0	1	6.5	4	-	-	-	-	-	-
TOTAL	71.6	100	103.1	100	162.5	100	1,873	100	3,861	100	9.074	100

TABLE 5-8: Forecast Electric Energy Demand by Consuming Sector: 1977 - 1995 (Gigawatt-Hours)

YEAR	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORTATION	TOTAL
1977	681,890	497,700	680,890	104,550	1,965,430
1978	725,130	530,040	730,840	108,550	2,094,910
1979	771,110	564,410	784,450	112,690	2,232,910
1980	820,000	601,000	842,000	117,000	2,380,000
1981	854,730	638,120	884,490	123,290	2,500,880
1982	890,930	677,540	929,120	129,910	2,627,900
1983	928,670	719,390	976,010	136,890	2,761,370
1984	968,000	763,820	1,025,260	144,250	2,901,630
1985	1,009,000	811,000	1,077,000	152,000	3,049,000
1986	1,039,500	849,220	1,124,430	158,940	3,172,400
1987	1,070,920	889,250	1,173,960	166,190	3,300,790
1988	1,103,290	931,160	1,225,660	173,780	3,434,380
1989	1,136,640	975,050	1,279,640	181,710	3,573,330
1990	1,171,000	1,021,000	1,336,000	190,000	3,718,000
1991	1,206,400	1,069,120	1,394,840	198,670	3,868,470
1992	1,242,860	1,119,510	1,456,270	207,740	4,025,040
1993	1,280,430	1,172,270	1,520,410	217,220	4,187,940
1994	1,319,140	1,227,520	1,587,370	227,130	4,357,440
1995	1,359,010	1,285,380	1,657,290	237,500	4,533,790

Water is essential to energy development and production--to extract materials from the earth, to process raw materials into usable fuels, to convert fuels into more usable forms of energy and to dispose of wastes from energy production. Water is also used directly for hydroelectric generation, for transportation of basic resources and fuels, and for dissipation of waste heat. Water is the working fluid of steam electric power production.

In 1975 steam electric power accounted for 94 percent of all water withdrawals for energy production, and 26 percent of total U.S. fresh water withdrawals. The consumption of water for steam power generation is, however, only 2 percent of the fresh water withdrawn.

The two principal methods of electric power generation in the United States are the conversion of heat energy to electricity by steam electric power plants (about 85 percent of the total national generation) and the conversion of potential energy to kinetic energy by hydropower (about 15 percent of the total national generation).

Water withdrawals to meet future energy demand will depend mainly on the composition of fuels and conversion methods used. For example, mining of coal requires less than 1 gallon of water per million British thermal units (Btu's), whereas extraction of oil and gas requires 3 gallons of water per million Btu. For processing, oil refineries need about 7.6 gallons of water per million Btu's, gas processing plants use about 1.7

gallons of water per million Btu's and nuclear fuel mining and processing require about 14 gallons of water per million Btu's. Thus, high use levels of nuclear sources of energy will result in higher withdrawals and consumption of water relative to the energy produced. Water requirements for energy production are summarized in Table 5-9.

In the year 2000, the average year withdrawals of water for electric generation are estimated at 62.4 BGD (80 percent) for nuclear plants and at 15.9 BGD (20 percent) for fossil plants. At that time electric energy production is estimated to be by a combination of 65 percent nuclear and 32 percent fossil fuels. These water requirements are summarized in Table 5-10.

Greater dependence on fossil and other fuel sources, except geothermal, would reduce water withdrawals. Moreover, the shortage of clean fossil fuels together with problems of synthetic fuels and alternative energy source technology could indicate that nuclear power production will increase exponentially in the next twenty-five years. However, the amount of water required by these power plants, plus the safety of nuclear facilities and their waste disposal problems, imply the contrary. The Federal Power Commission has estimated that by 1990, withdrawals of water for condenser cooling may be approximately one-sixth of the total average flow of all the rivers in the contiguous United States.[49] While such statements do not

TABLE 5-9. Water Requirements for Energy Production by Type of Fuel and Process

	Type of Fuel/Process	Standard Unit	Water Requirements Std. Unit (gallons)	Water Requirements Million BTU (gallons)	Major Water Use
COAL	Western Coal Mining	ton	6.0-14.7	0.25-0.61	Dust control & washing
COAL	Eastern Coal Mining	ton	15.8-18.0	0.66-0.75	Dust control & washing
COAL	Coal Gasification	MSCF*	72.0-158	72-158	Process and cooling
COAL	Coal Liquification	barrel	1134-1750	31-200	Process and cooling
PETROLEUM	Oil and Gas Production	barrel	1.7-3.0	3.05	Well drilling and recovery
PETROLEUM	Oil Refining	barrel	43.0	7.58	Process and cooling
PETROLEUM	Oil Shale Production	barrel	145.4	30.1	Mining, cooling processing & waste disp.
PETROLEUM	Gas Processing	MSCF*	1.67	1.67	Cooling
	NUCLEAR FUELS	-	-	14.3	Mining and Processing
POWER GENERATION	Fossil Fuels	kwh	0.41	120.16	Cooling
POWER GENERATION	Nuclear Fuels	kwh	0.80	234.46	Cooling
POWER GENERATION	Geothermal	-	-	527	Cooling and extraction

*Million Standard Cubic Feet

TABLE 5-10. Estimates of Water Withdrawals for Total Energy Consumption and Electric Power Generation by Source of Fuel: 1975, 1985, 2000 (Average Year)

Type of Fuel Used	Total Energy Consumption						Electric Power Generation					
	1975		1985		2000		1975		1985		2000	
	BGD	%	BGD	%	BGD	%	BGD	%	BGD	%	BGD	%
Fossil	76.9	82	45.0	45	20.8	24	71.8	81	40.2	42	15.9	20
Nuclear	17.3	18	54.7	55	64.2	76	17.3	19	54.7	58	64.2	80
Hydro	-	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	94.2	100	99.7	100	85.2	100	89.1	100	94.9	100	80.1	100

pinpoint specific problem areas, they do serve to indicate the magnitude of energy production problems on a water basis.

Coal is frequently cited as an alternative feedstock for power production and its use is likely to increase in the near term (to 1985). At present, two-thirds of coal produced is converted to electric power. Increase of this usage involves technological (mining and processing) and environmental (air emissions) problems. Moreover, shortness in supply of water in many areas of high coal availability (e.g., the High Plains) and the increasing requirements that clean water only be released from industrial plants are among the additional obstacles to establishing new power plants.

Among the alternatives to power production, ocean thermal power plants (OTEC) are of interest. These plants capture the sun's warmth in ocean surfaces and utilize the temperature differences of surface and subsurface waters to generate electricity. Warm sea water from the ocean surface and cold deep water below are pumped through a heat exchanger that employs a working fluid, such as ammonia, propane or freon in a classical cold cycle. The warm water vaporizes the working fluid which is expanded through a turbine. The electricity generated can be transmitted via cable from the offshore plant to shore and integrated with an existing energy grid. Alternatively, it can be used on-site for processes such as uranium enrichment or hydrogen production. It is unlikely that OTEC

plants will provide a substantial portion of total electricity demand by the year 2000.

Factors that are major in determining the development of power plants include: environmental, economic, social, legal, health and land use issues. The design, location, construction and operation of electrical power generation facilities are affected by concerns for the environment. Specific issues are particulate emissions and gaseous pollutants, and thermal and solid waste pollution. The use of coal and shale to produce synthetic oil and gas increases environmental risks due to the presence of toxic trace metals and organic carcinogens inherent in minerals processing.

Drift deposits from cooling towers transport various types of chemical compounds. Salt deposits can damage surrounding areas and adversely affect the soil properties. Chlorine content of the ground waters may be increased. Water impacts include thermal pollution, chemical toxicity, entrainment and entrapment of aquatic organisms, and dissolved oxygen depletion. The dispersion of thermal discharges can produce lasting effects on aquatic life.[50]

The use of all fossil fuels, including coal-based synthetic fuels, increases the carbon dioxide content of the atmosphere. Increased carbon dioxide emission can produce a "greenhouse effect"--the trapping of outgoing infrared radiation from the earth's surface. Impacts of radioactivity from nuclear power plants have been well documented.[51]

OTEC plants would operate within the U.S. territorial sea and would, therefore, be subject to federal regulations regarding plant discharges. Accidental discharge of various working fluids could pose unique problems. The erection of ocean-based structures would have to be sited to minimize hazards to navigation as well as commercial fishing. Additional impacts would result from laying cables for electricity distribution to shoreside facilities.

Utility financing because of the heavy costs and future uncertainties involved is a most difficult issue to assess. The future price of fuel for generating electricity cannot be determined with any degree of accuracy and this factor alone could determine the feasibility of future power plants.

Special incentives are presently being considered to spur the development of commercial-scale alternative energy sources and synthetic fuels. The proposed Energy Securities Commission and Energy Mobilization Board, plus numerous demonstration grants available through DOE are examples. Regulatory requirements and environmental factors have been translated into project delays, affecting overall energy project financing. Some form of government intervention, either to stabilize regulatory/environmental requirements or to guarantee prices, will be required.

Both the physical construction of the plant and the changing social structure affect land use patterns. Agricultural land is converted to residential property. Urban oriented

community development projects are initiated in rural areas. Zoning structures change. Building permit and code enforcements deviate under pressures for new construction.

Land use conflicts are especially acute in coastal zone areas and along rivers as power plants compete with other industrial developments. The competition for water rights is even more critical, especially in the West. In this region of the country it is not unusual for a utility to purchase large tracts of agricultural land in order that the water rights associated with the land might be gained. The water, once used for irrigation, is used for cooling. The land, once tilled, is left fallow.

A recent study has set forth several recommendations to improve investigation and mitigation of impacts in the sociological area. First, the community's ability to manage expected impacts should be established. Second, the community should develop a plan for meeting the impacts of the new power plant. Third, the state should interact with the community by providing resource support where needed. Finally, joint state/local planning should be initiated to facilitate a response to new unexpected impacts unique to the community. With such an approach, social impacts associated with power plant siting can be mitigated.

Generalizations on the sources and the nature of delays in the licensing process of nuclear and fossil plants

are difficult to make because of the site-specific characteristics of each situation. One cause of delay is that most plants are custom designed. Increased standardization would minimize this delay. Delays in the licensing process can also be attributed to: (1) the lack of utility responsiveness to staff or reviewer requests for data, (2) continually changing requirements as to the format for data submissions, (3) understaffed review agencies that contribute to long turn-around times, (4) inordinate amounts of paperwork that must be processed, (5) the complexity of state and federal agencies involved in the siting process, and (6) the recent trend toward intervenor activity.

No conclusive evidence has been developed to establish the specific causes of delay. Continuing study in this area may one day settle upon the specific mechanisms that create delay and lead toward specific recommendations for a more effective and efficient process. A recent staff report from the Office of State Programs of the NPC has been developed, based upon the experience of that agency, that presents suggestions for decreasing delays and improving the licensing and regulatory effectiveness in joint federal/state siting actions. Such evaluations are helpful in creating a public awareness of the deficiencies that must be addressed as viewed from the perspective of a reviewing agency.

Hydropower

Water power resources or water wheels have been in use for centuries for performing mechanical work. In the United

States, the early settlers of New England used water power for grain milling.[52] The use of water power for industrial processes began in the U.S. in the 1880's. The first substantial water power development in the U.S. was on the Merrimac River in Massachusetts in 1882.[53] The first hydroelectric power development in the U.S. was built in Niagara Falls in 1879. The first central hydroelectric power station for the production of commercial electricity for incandescent lighting was on the Fox River in Appleton, Wisconsin, in 1882. Subsequently, many new sites for electrical power production were developed. By 1920 hydroelectric capacity exceeded 5000 Mw. By 1930, hydropower provided 40 percent of the nation's electric energy.[54]

By 1950, dependence on hydropower for electric generation began to decline. By 1970, its share was less than 15 percent of the nation's generating capability.[54] This decline was due to the availability and costs of fossil fuels for energy production. The capital costs for thermal energy production were substantially less than that for hydropower. While fuel prices were stable and relatively inexpensive, hydropower facilities were not cost competitive.

The Water Resources Development Act of 1976 and President Carter's Energy Plan of 1977 emphasized the importance of hydropower. Section 167 of the Act authorized the U.S. Army Corps of Engineers to provide a current and comprehensive estimate of the potential for incremental or new generation at

existing dams and other water resource projects, as well as for undeveloped sites in the U.S. This study (The National Hydroelectric Power Study) is in progress and scheduled for completion in the fall of 1981.

The Energy Program of 1977 recognized the opportunity for redeveloping small-scale hydropower as an alternate source of energy. Further, the President directed the Corps of Engineers to produce summary estimates of the potential at existing small dams in the United States. Corps of Engineers efforts are to include an investigation of the hydroelectric potential at federal installations, as a component of their other water resource projects.

The potential of hydropower electric generation is being defined by the Corps of Engineers. The resource that could be developed is estimated, by the Corps, to exceed 512,000 megawatts of capacity, nationwide, with an average annual generating capacity greater than 1,400,000 gigawatt-hours. This potential is summarized in Table 5-11.

Presently there are, in the United States, over 5,400 existing large-scale dams which could be expanded for additional power production. Full development of these existing dams would provide an additional capacity of 94,000 megawatts with an average annual generating capacity of approximately 223,000 gigawatt-hours. There are an additional 4,500 potentially feasible, but yet undeveloped, large-scale sites. If fully developed, these sites could produce another 354,000 megawatts

TABLE 5-11. Summary of Hydropower Potential

Potential	No. of Sites	Installed Capacity (Megawatts)	Installed Generation (Gigawatt-Hrs.)
Large-Scale			
Existing	5,400	94,000	223,000
Potential	4,500	354 000	935,000
Small-Scale			
Existing	5,600	5,400	17,000
Potential	2,600	8,000	28,000
Potential	181,000	461,400	1,203,000
Present Facilities	1,251	64,000	280,000
Total Resource		525,400	1,483,000
1979 Consumption of Electricity			2,100,000

Note: 280,000/2,100,000 = 13 percent which is the present share of electric power provided by hydropower in the U.S.

with an average annual generating capacity of approximately 935,000 gigawatt-hours.

There are over 5,600 small-scale dams in the country which are either producing hydroelectric power or have the potential for production. The installed capacity of these small-scale facilities is estimated to be approximately 3,000 megawatts with an annual generating capacity of approximately 15,000 gigawatt-hours. Incremental capacity that could be realized at these existing small-scale dams is approximately 5,400 megawatts with an annual generation rate of 17,000 gigawatt-hours. Further, there are approximately 2,600 potentially feasible, but as yet undeveloped, small-scale sites that could be developed providing a capacity and generation rate of, respectively, 8,000 megawatts and 28,000 gigawatt-hours annually.

The prime barriers to the development of new sites for the production of electricity by hydropower are lead time required and resource location. The lead time required for financial and project planning, field surveys, site-specific analyses, design and construction is approximately 20 years. Most of this time would be required to overcome the considerable opposition to the development of new dams and the current procedures available to effect a resolution to that op[illegible]. Additionally, the largest undeveloped resource in the U.S. is located in Alaska. The energy demand in Alaska will not justify large-scale development.[55] The existing political situation

for the development of large-scale transmission of power from Alaska to the lower 48 states obviates development for consumption outside of Alaska.[55] It is doubtful that new sites will be developed over the next 20 years.

Engineering or technology barriers include: engineering techniques for small facilities; rehabilitation of existing dams; and the design of transmission/delivery systems. Electro-mechanical technology for low-head turbines in the United States is limited. Low demand has resulted in limiting manufacturing capacity to build and deliver such turbines: the existing number of low-head hydroelectric facilities in the U.S. have been designed and fabricated as a custom unit. Individual unit development would be too cumbersome and expensive for major development of this resource. Development of low-head facilities on a national scale would require the planning and establishment of a manufacturing capability to mass-produce turbines. It would also require the establishment of a standard practice and codes for turbine assemblies and other equipment.

Dams constructed of earth-fill and rocks have lifetimes of approximately 100 years, while concrete structures have one-half that lifetime. Many of the existing dams in the U.S. were constructed prior to 1930 and these are in need of rehabilitation. The extent of rehabilitative efforts and the number of dams affected is unknown but estimated by the Corps of Engineers at approximately 4000. Since the extent of work required is unknown,

the associated costs are unknown. In a recent publication, the Corps of Engineers assumed that the costs of rehabilitating half of the dams built prior to 1930 would be prohibitive.[56]

A related problem is the height of the dam. Existing dams on streams that are silt-laden have lost much of their effective height. The Corps has assumed that one-half of the pre-1930 dams in the Midwest and Southeast retain only 50 percent of their effective storage capacity. Rehabilitation could include additional height, but cost considerations would dominate. Dredging is possible but is expensive and subject to environmental opposition, primarily due to noise of equipment, aesthetics, disruption of benthic communities and disposal. Disposal of dredged material is already a major problem associated with maintenance of navigation.

Transmission of power assumes a constant supply of electricity to be transported. Many of the existing hydroelectric plants (small-scale) are situated on streams which have a zero dry-weather flow. For a steady power supply, numerous small facilities would have to be coupled. Additionally, these small-scale facilities are normally situated in remote locations. The construction of transmission lines is expensive and is subject to environmental opposition due to land requirements, maintenance of rights of way (effects to terrestrial biological systems) and aesthetics.

Traditionally, the largest cost of hydroelectric facilities is capital. "Fuel" costs are considered as free.

The traditional advantages of hydropower are economic in that its useful lifetime is two to three times that of thermal plants; O&M costs are low because of the relative simplicity of the equipment; and the facilities can respond rapidly and easily to variations in demand. Thermal power plants are traditionally lower in capital investment but incur higher O&M costs, additional equipment for varying (peak) demand, and have fuel costs. The price of fossil fuels is an important factor. A recent study by MITRE[57] shows that capital expenditures plus recent increases in fossil fuel costs for thermal facilities have made many hydroelectric sites economical.

Increased fossil fuel prices plus the sunk capital in existing dams would indicate that hydroelectric power should have economic advantages. However, an Engineering News Record survey in 1977 of 30 utilities revealed little interest in hydropower and indicated retirement of present facilities. The reason for this is that the fuel of hydroelectric power production is not free.

A survey by the Corps of Engineers[56] revealed that the water impounded by existing dams has other uses including irrigation, flood control, water supply and recreation. An example presented in the reference shows that the revenue generated (at one dam) as a water supply is approximately four times that which would result from power production. Additionally, impoundments for flood control, irrigation or water supply cannot be readily adapted to power generation.

The primary environmental impacts of hydropower production are associated with induced changes in stream flow and the effects of frequent filling and drawdown of reservoirs. These effects are to benthic and other aquatic communities, including fish migration through obstructions, and to terrestrial organisms.

Social impacts are significant. These include possible conflicts with other uses of the water resources (e.g., recreation), health effects, and safety considerations (e.g., fluctuating water levels and dam ruptures) and attitudes. Attitudes are affected in terms of reliance on small-scale systems, decentralization of power supply, and perceptions of energy conservation. For example, reliance on power provided by water resources, during a period of drought or low stream flow conditions could severely stress social attitudes.

The majority of dams in the United States are privately-owned and operated. Only 5,500 out of 49,500 dams in the U.S. are owned and operated by the Federal Government. Private ownership includes state and local governments, public and private utilities, industries and private corporations. Each owner operates with a particular set of legal and institutional constraints imposed by: (1) regulatory agencies; (2) riparian or appropriation water laws; (3) individual, community or corporate values, goals, beliefs, customs, etc.; (4) treaties, constitutions, charters, ordinances, by-laws; (5) economic and financial climate; and (6) short-term and long-term goals.

An effort to coordinate hydropower as a national resource would have to address the constraints identified above and evolve workable agreements by all parties involved. Efforts are underway in licensing and in demonstration projects. These actions must successfully bridge contradictory and conflicting goals or requirements; otherwise delays in developing hydropower resources could preclude utilization of the potential.

Only a small percentage of the potential hydroelectric resources will be developed by the year 2000. Recent surveys have shown, prior to the fuel-supply crisis of 1978-79, hydropower facilities were being retired with no new facilities being developed. The primary reason for retirement is due to the multiple uses of stored water, other than for power production, and the relative economics of those other uses. Forecasts available indicate a probable increase of only one percent in capacity with an actual decrease in generation. The most optimistic generation rate for the year 2000 is less than the present generation rate.

The development of major new hydropower sites is unlikely due to the remote location of candidate sites (Alaska) and due to legal/institutional constraints. Reference 55 concludes that there w[illegible] be no new major developments over the next 20 years.

CHAPTER 6 SCENARIO DEVELOPMENT

The preceding five chapters have outlined the present and forecast the future status of water scarcity in the United States. The findings are as follows:

- With respect to surface water, there is in general more than an adequate supply to meet all demands; however, there are local, and even regional, shortages due to distribution inequities and to pollution.

- The situation is similar for groundwater supplies, except in some regions where water is being withdrawn and consumed at a rate that greatly exceeds recharge.

- The transfer of water (ground and surface) from water rich areas to regions of scarcity is logical, but is discouraged due to water rights, environmental issues, economics, and public attitudes. Federal policy discourages such projects.

- Technological innovations to extend water supply, other than land-based desalination processes, are not yet feasible. Large scale weather modifications, ocean-going desalination plants and iceberg transport are some of the technologies to extend water supplies. These, however, are either in experimental stages or are severely limited by the economics of conversion. None of these technologies are likely to be in large-scale use by the year 2000.

- Technological innovations to decrease demand and consumption exist, but these are limited by economic considerations, by pollution control legislation, and by present federal policy (as well as limitations on funds from federal agencies responsible for policy implementation). For example, water withdrawals for steam-electric generation could be reduced by 25 to 30 percent by means of dry cooling towers that use no water, but do require more energy to operate and are expensive. Irrigation is another prime candidate for

water conservation but installation costs for water reducing technology are often not justified under current water and agricultural price relationships.

- Thirteen regions of the United States are expected to experience water supply problems over the next twenty years.

- Examination of forecasts of industrial, agricultural, energy, domestic and recreational activities, in these thirteen regions, all reveal growth, with no tradeoffs between growth activities in any one region being demonstrated.

- Competition among growth activities for scarce water resources will occur.

- Regional problems of competition, including state and local community problems, will be solved at the regional, state and local level. Federal policy and pollution control legislation encourages this approval.

- The role of the Federal government and its agencies is to foster and assist local problem resolution.

The Coast Guard is a Federal agency with responsibilities that are water dependent. It is the world's largest marine police force and one of the most powerful of Federal law enforcement agencies. Any water scarcity, inland or coastal, would have a strong influence on those of its growing responsibilities that require research activity and would affect its personnel and equipment requirements, in terms of both numbers and capabilities. In order to evaluate the effects of water scarcity on the USCG in greater detail, several scenarios have been developed and analyzed.

The regions of the US expected to experience a water supply problem were related to the USCG geographically. The

FIGURE 6-1: U.S. Coast Guard Districts

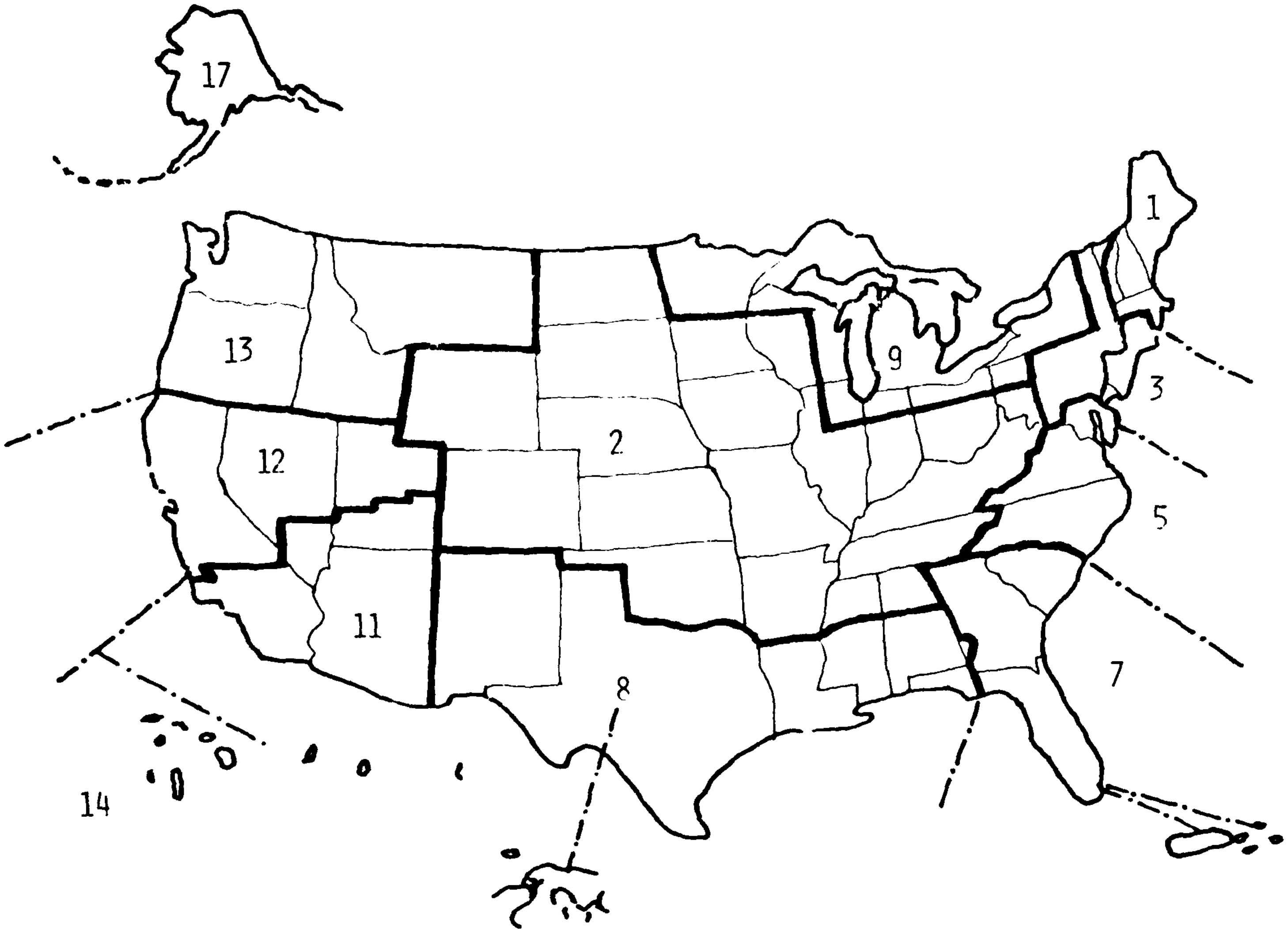


TABLE 6-1: U. S. Coast Guard Districts Expected to be Affected by Water Scarcity

Basin Experiencing Water Scarcity Problem	1 Boston, MA.	2 St. Louis, MO.	3 New York, N.Y.	5 Portsmouth, VA.	7 Miami, FA.	8 New Orleans, LA.	9 Cleveland, OH.	11 Long Beach, CA.	12 San Francisco CA.	13 Seattle, WA.	14 Honolulu, HA.	17 Alaska	No. of Districts Aff.
South Atlantic Gulf				x	x	x							3
Upper Mississippi		x					x						2
Lower Mississippi		x				x							2
Missouri		x								x			2
Arkansas-White-Red		x				x							2
Texas Gulf						x							1
Rio Grande		x				x							2
Lower Colorado						x		x					2
Great Basin									x				1
Pacific Northwest										x			1
California								x	x				2
Caribbean					x								1
No. of Basins Affect.	0	5	0	1	2	6	1	2	2	2	0	0	21

USCG districts were superimposed on those geographical regions of the US forecasted to experience water shortages. USCG districts are defined in Figure 6-1. Regions of water scarcity were defined and discussed in Chapter 2. The superposition of both data sets is summarized in Table 6-1, and reveals that:

- Eight of the 12 existing USCG districts are within regions that are experiencing, or will experience, water scarcity; and
- With the exception of three regions (the Great Basin, the Pacific Northwest, and the Caribbean) multiple U. S. Coast Guard Districts have jurisdiction (typically two districts), over projected water-scarcity areas.
- With many USCG regions impacted by water scarcity problems, the USCG headquarters will be involved on both the administrative policy-making levels.

Further, the nature of the regional water scarcity problem and the overall role of the Federal government were examined. The results of this examination are presented in Table 6-2. The table also includes a summary of which major water scarcity issue is expected to predominate over the next 20 years. This analysis reinforced the above conclusion that USCG Headquarters will be impacted by a water scarcity problem. For example, in the Texas Gulf region port congestion will continue to be a problem. From Table 6-1, two USCG Districts are involved. Coordination of their responsibilities will be required. Additionally in the South Atlantic Gulf region, the USCG interface with the Corps of Engineers will be important.

TABLE 6-2: Summary of Water Scarcity Problems and Anticipated Role of Federal Government

Basin Experiencing Water Scarcity Problem	Coastal Region	USE: Industry	USE: Irrigation	USE: Electricity Generation	PROBLEM: Distribution of Sources	PROBLEM: Overdraft of Groundwater	PROBLEM: Instream Use Conflicts	PROBLEM: Flooding	PROBLEM: Maintenance of Navigation	ROLE OF FEDERAL GOV'T.: Institutional	ROLE OF FEDERAL GOV'T.: Planning	ROLE OF FEDERAL GOV'T.: Research & Development	ROLE OF FEDERAL GOV'T.: Construction/ Navigation Sys	ROLE OF FEDERAL GOV'T.: Assist State Studies	MAJOR ISSUES
South Atlantic-Gulf	x	x			x	x		x	x		x	x	x		Dredge & fill-in wetlands
Upper Mississippi							x	x	x	x	x	x			Localized, periodic drought
Lower Mississippi	x				x			x	x	x	x				Flooding is a major problem
Missouri										x				x	Water rights issues
Arkansas-White-Red		x	x	x											Balancing supply and demand
Texas Gulf	x		x			x		x						x	Port congestion
Rio Grande			x			x								x	Supply equals demand now
Lower Colorado			x			x						x			Demand exceeds supply now
Great Basin			x			x								x	Demand exceeds supply now
Pacific N. W.	x		x		x		x			x					Seasonal shortages
California	x		x		x			x		x	x	x			Distribution of supplies
Caribbean	x		x		x					x	x				Poor distribution systems & mgmt.

Data were examined in order to isolate the present USCG position and role with respect to water resources. The overall USCG mission is described in terms of its seven major objectives, as summarized in Table 6-3. Because of geographic variability throughout the US, implementation of the mission by the different Coast Guard Districts must also vary.

An approach to scenario definition is first to consider alternative responses to a water scarcity problem. To do this, several definitions and assumptions were made; they are identified in Table 6-4.

In this approach, the possible responses to a water scarcity problem, regardless of cause or regional (geographic) extent, were considered in terms of actions that would:

- Increase the available supply,
- Modify the demand,
- Do nothing.

Next, for each generic response, actions were structured to implement that response. These actions were identified from the findings of the study. The actions selected are given in Table 6-5 under each generic response heading.

Ways to increase or extend water supply include all of the technological advances described in Chapter 5, as well as institutional and policy reorientations investigated in Chapter 4. The policy actions are consistent with current Federal policy

TABLE 6-3 Mission of the U. S. Coast Guard

- To minimize loss of life, personal injury and property damage on, over and under the high seas and waters subject to U. S. jurisdiction
- To facilitate transportation with particular emphasis on waterborne activity in support of national economic, scientific, defense and social needs
- To maintain an effective, ready-armed force prepared for and immediately responsive to specific tasks in time of war or emergency
- To assure the safety and security of vessels and of ports and waterways and their related shoreside facilities
- To enforce federal laws and international agreements on and under waters subject to the jurisdiction of the U. S. and under the high seas where authorized
- To maintain or improve the quality of the marine environment
- To cooperate with other governmental agencies and entities (Federal, state and local) to assure efficient utilization of public resources and to carry out activities in the international sphere where appropriate in furthering national policy

Source: ICOMDITINST 16014.1, 1979

and are probable actions. Actions listed under "modify demand" were obtained in a similar manner. Actions listed under the third generic response constitute probable consequences of not responding.

Each probable response was determined in terms of its affect or impact on the U. S. Coast Guard. The U.S. Coast Guard mission, as defined in Table 6-4, was used as the basis for characterizing responsibility. It was determined whether and how each response would impact the Coast Guard in terms of the missions components. The results of this impact identification process are presented in Table 6-5 (an "x" in any of the mission columns indicates impact.)

For example, if water supply is extended by technological advance (e.g. transport of icebergs), the U. S. Coast Guard would be heavily involved (perhaps in the towing operation, and once the iceberg entered U. S. territorial waters). This involvement could include safety and rescue, maintenance of navigation, security of ports and vessels, enforcement of Federal law (unless certain waivers were obtained), and cooperation with other governmental agencies. The U. S. Coast Guard could also be responsible for certain R&D related to the effects of operations such as iceberg transport on the marine environment. In the case of increased use of treated wastewater, the U. S. Coast Guard would be involved in terms of enforcement of Federal water-pollution laws, and perhaps in R&D for effects of the use or disposal of this water (if any) on the marine environment.

TABLE 6-4 Key Definitions and Assumptions for Scenario Development

Definitions

Water Scarcity	- Disruption of the available fresh water supply as related to demand, such that all water-related activities cannot continue as in the past and that priorities must be established and allocations must be made.
Impact	- Changes caused, both directly and indirectly, by water scarcity.
U. S. Coast Guard	- An organization within the Executive Branch of the Federal government with prescribed responsibilities (mission) and budget authority to carry out those responsibilities.
High Impact	- Significant departure from past or planned practices.
Low Impact	- Minor departure or interruption from past or planned practices.

Assumptions

The U. S. Coast Guard mission is defined by seven individual responsibilities.

All elements or responsibilities of the USCG's mission have equal priority.

The nature of the performance of each mission element is in part dependent upon the geographic locations of the U. S. Coast Guard bases and units assigned that responsibility.

TABLE 6-5: Possible Effects of Water Scarcity on the U. S. Coast Guard

Possible Responses to Water Scarcity	Minimize loss of life, pers. injury & property damage	Facilitate water forne transportation	Maintain an effective armed force	Safety & security of ports & vessels	Enforcement of Federal Laws	Maintain & improve quality of Marine Environment	Cooperation with other governmental agencies	
• Increase Water Supply								
-Negotiate treaties for importing from Canada and exporting water to Mexico	-	-	-	-	x	-	x	
-Transportation of Icebergs	x	x	-	x	x	x	x	
-Greater use of saline waters	x	x	-	-	-	x	x	
-Increase the number of desalination plants	x	x	x	x	x	x	-	
-Increased use of treated wastewater	-	-	-	-	x	x	-	
	3	3	1	2	4	4	3	(20)
• Modify Demand for Water								
-Establish and implement priorities	-	-	-	-	-	-	-	
-Reuse and recycle of process water	-	-	-	-	x	x	-	
-Utilization of water conservation devices	-	-	-	-	-	-	-	
-Mandated water conservation management	-	-	-	-	-	-	-	
-Establishment of ocean-based energy production	x	x	x	x	x	x	-	
-Increased minerals production from the ocean	x	x	x	x	x	x	-	
	2	2	2	2	3	3	0	(14)
• Do Nothing								
-Violations of existing treaties with Mexico	-	-	-	-	-	-	-	
-Localized emergency situations	x	x	x	x	x	x	x	
-Increased reliance on fish protein	x	x	x	x	x	x	-	
-Food production from the oceans	x	x	x	x	x	x	-	
-Decreased export of food and manufactured goods	x	x	x	x	x	x	x	
-Increased imports from foreign countries	x	x	x	x	x	x	x	
	5	5	5	5	5	5	3	(33)

The numbers of correlations between responses and the components of the U. S. Coast Guard mission were determined and used as a basis for structuring the impact scenarios. The following scenarios resulted:

Low Impact:	Water scarcity occurs and a "modify demand" response is adopted.
Probable Impact:	Water scarcity occurs and an "increase supply" and "modify demand" response is adopted.
High Impact:	Water scarcity occurs and a "do nothing" response is adopted.

In the low impact scenario, planned and coordinated actions are implemented to modify the demand for available supplies. Local and regional plans are implemented in conjunction with Federal resources, such that no large-scale disruption occurs. Demand management strategies, such as conservation, are strictly and widely enforced by means of legal penalties. Water conservation to modify demand may mean reduction of water use to some, development of new supplies to others, and curtailment of certain uses of water to still others. Water conservation measures proposed for certain in-stream uses of water such as navigation and recreation would involve Coast Guard participation. Navigation improvements could require dredging of channels to maintain channel depth, disposal of dredged material, and construction of locks, dams, and impoundments. Where widening and deepening of coastal, harbor, and

channel dimensions needed to accommodate ever-increasing waterway traffic has been postponed for reasons related to water scarcity, dangers to the safety and security of vessels, ports, and waterways will remain, requiring an increased involvement of the Coast Guard. The Ports and Waterways Safety Act of 1972 gave the Coast Guard responsibility for safe transportation of dangerous cargoes on navigable waters of the United States. Congestion of waterways caused by lowered water levels, and consequent decrease in the depth of channels and narrowing of water courses, could pose additional hazards to water transport, and in particular, to transport of dangerous cargoes, adding regulatory functions to the Coast Guard and increasing its safety-related activities. Furthermore, reduced in-stream flow resulting from allocation of water for competing uses such as agriculture and energy, can endanger public safety and water quality. The 1971 Federal Boat Safety Act requires the Coast Guard to serve as a watchdog for boating safety. Additionally, in 1970 and 1972, the Water Quality Improvement Act and the Federal Water Pollution Control Act gave the Coast Guard increased statutory responsibility for making and enforcing regulations concerning water pollution and polluters.

The most probable impact scenario includes efforts to both increase supply and modify demand. In this instance, a greater reliance on ocean based desalination, energy production and mineral mining occur. All of these impact the U. S. Coast

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Guard. Simultaneously, there is improvement in agricultural management practices, coupled with reuse and recycle, use of conservation devices, and, perhaps, use of treated wastewater (direct or indirect) for aquifer recharge. These actions are accompanied by a campaign of awareness to inform both corporations and individuals as to the severity of the occurrence and the options available to remedy the situation. Voluntary citizen and industry support is obtained.

In the high impact scenario, unplanned and uncoordinated responses occur, primarily by sectors of the economy or by regions of the United States. Food and energy supplies will be required. To maintain adequate supply (and perhaps exports or trade), available water supplies are consumed and a trend toward greater reliance on ocean resources develops. In this scenario, the Federal, state, and local governments respond to individual problems rather than anticipate and direct.

DIRECT EFFECTS OF WATER SCARCITY ON TRADITIONAL ELEMENTS OF THE COAST GUARD MISSION

Conditions of water scarcity caused by drought or by the expected great increase in withdrawals, from both surface and groundwater, for industrial, power development, agricultural, and normal human uses could result in substantial lowering of water levels in the navigable inland and estuarine waterways of the United States. The Coast Guard mission is vitally bound to commerce on the inland waterways, including aids to navigation;

traffic control; bridge administration; pollution and hazardous material spill prevention, containment, and clean-up; fire-fighting; and safety, including recreational boating safety.

The width and depth of the navigable channel, and of the total water-course, change with the river stage. Current velocity also fluctuates with changes in stage--channels shift and may be narrowed, channel depths may decrease, and sandbars are built or destroyed; thus channel bouys must be shifted, dredging activity must be increased, traffic control is affected, etc. Spills and leakage are increasingly likely under conditions in which channel depths are decreased, and tank carriers are more likely to contact the bottom or strike bars or other obstacles exposed by lowered water levels.

The amount of hazardous cargo transported by water is likely to continue to increase, and new hazardous products will appear.

As noted in the 1971 Coast Guard report on Ports and Waterways, the chemical industry in this country, which produces most of the hazardous materials shipped in bulk, has been growing at a rate substantially larger than the country's overall industrial growth rate. Concurrently, water transportation of these hazardous products has increased rapidly in certain parts of the country, notably on the western rivers and inland waterways and along the western half of the Gulf Coast. The result has been traffic congestion and a high incidence of marine accidents

in certain ports and waterways. Most of these areas, moreover, are within or near densely populated cities where massive release of toxic substances could have drastic effects. Lowering of water levels in such rivers and waterways as a result of excessive withdrawals for agricultural, industrial, and human use, from both surface and groundwater sources, would aggravate these problems by reducing the depth of channels, narrowing the water courses in general and navigation channels in particular, increasing sedimentation (hence, channel filling and growth of sandbars), reducing the volume of water available to dilute and disperse pollutants (lowered stream velocities associated with diminution of flow would also contribute to this problem), and perhaps in other ways.

Factors of great importance with respect to collisions, groundings, and other accidents involving vessels in heavily congested waters are: channel depth and configuration; navigational aids (adequacy and correct placement, especially under conditions of rapid, large physical changes in the water course); the presence of abnormal, or new and unexpected, obstructions; currents and prevailing winds; and others. All but winds are likely to result from lowered water levels due to water scarcity. In low-water situations, water-side approaches to fires may be more difficult--especially to onshore or near-shore fires. Under these conditions, greater reliance on helicopter transport of fire-fighting equipment and firefighters might be required.

Severe inland water scarcity would probably stimulate increased development of various ocean-based activities, including both onshore and off-shore desalination facilities, as well as off shore industrial and mining projects. Some inland recreational activities might also move to estuarine and near-shore oceanic areas. Such activities as illegal ocean dumping and drug trafficking are also likely to increase over the next two decades. All of these developments will have a direct bearing on the mission and day-to-day work of the U. S. Coast Guard; in particular, the enforcement, search and rescue, and safety elements of the Coast Guard mission are likely to be the most affected.

CHAPTER 7 LOW IMPACT SCENARIO: WATER SCARCITY OCCURS AND A "MODIFY DEMAND" RESPONSE IS ADOPTED

In the Low Impact scenario, planned and coordinated actions are implemented to extend available supplies and to modify the demands. Regional plans are implemented in conjunction with Federal resources, such that no large-scale disruptions occur. Today's ongoing regional planning, increasing augmentation of existing supplies via desalination projects, and modification of demand via water reuse and recycling processes, and input of Federal funds, are typical of the Low Impact scenario.

As water withdrawal and consumption increase, as forecast for the next 20-year period, concurrent planned and implemented procedures for increased augmentation, demand modification and continuing Federal support will maintain the water scarcity problem at a manageable level, i.e., low impact. The impact of this kind of response pattern on the USGC will be a concurrent, planned increase in its responsibilities in guarding the safety of personnel and property, along the coasts and offshore, as desalination complexes are developed in those areas, and as offshore power production facilities are increased.

ROLE OF GOVERNMENT

Planning

Government (Federal) will continue to monitor the planning of the regional, state and local water authorities and respond to their requests for such technical and legal

assistance as they may require. It will not actively engage in their planning activities, but may provide guidance in the form of directives, statements of national goals, etc.

Allocation of Resources

The Federal government will provide financial assistance, total and/or matching, to assist the regional, state and local planning agencies in the implementation of their respective water supply enhancement programs. Technical assistance on a limited basis for data acquisition or for policy implementation will be provided.

Relationships of Units of Government

A continuing Low Impact situation regarding water supplies should not cause any significant alteration in the relationships between units of government. Variation in budget allocations may occur as changing conditions require changing focus/emphasis on the part of different governmental units but the basic, current relationships should remain essentially unchanged.

CANDIDATE TECHNOLOGIC ADVANCES LIKELY TO BE IMPLEMENTED

The feasibility and state-of-the-art regarding fresh water conservation and augmentation technologies have been addressed in Chapter 4; however, the most likely candidate technologies to be implemented in the Low Impact scenario are salt and/or brackish water desalination (conventional, solar

or nuclear powered) on and offshore, water recycle and reuse in industry and agriculture.

At present, there are about 500 land-based desalting plants producing about 100 million gallons of fresh water per day for municipal and industrial uses in the U.S. Distillation with multi-flash distillation seems to be the most widely practiced desalting technique currently being used. However, desalination is currently highly uneconomical and this seems to be the major deterrent to any large scale application of desalination. The feasibility of using solar energy as a power source, and solar energy in combination with various conventional sources seems to hold high prospects to lowering cost. However, such techniques are still in developmental stages.

Water reuse and recycle are getting greater attention and acceptance both by the industry and agriculture. Reuse requiring water of secondary quality is considered economically feasible. These include agricultural irrigation, livestock and wildlife watering, once-through cooling and process water for primary industries. It is projected by OWRT that water reuse would undergo a four-fold increase growing from 0.2 percent of freshwater withdrawals in 1975 to 1.7 percent in 2000.

ROLE OF U.S. COAST GUARD

In the Low Impact scenario, certain elements of the USCG mission may, with the passage of time, require increased

emphasis but such increase in emphasis will be evolutionary rather than revolutionary. The major policies for implementing these USCG mission objectives include:

- Encouragement of state and local government participation in rule-making processes and in solving problems in areas of concurrent jurisdiction and assumption of the leadership role when appropriate;

- Expansion of R&D efforts to include larger term, high pay-off projects but not at the expense of the near-term problems. This may include the development of hardware, procedures and systems as well as the expansion of knowledge related to technical support for regulatory programs. Projects may have to be structured to meet the immediate needs of agriculture and energy production while anticipatory and innovative research could contribute to long term needs;

- Continual alertness for trends towards threats to the safety and security of ports;

- Continuing to seek ways to facilitate marine transportation consistent with safety and marine environmental protection objectives;

- Keeping abreast of the water quality in the far distant ocean regions (7,200 mi.) with a view toward detecting the first signs of environmental deterioration;

- Continuing to focus the public's concerns on the need for small boat operating safety; and

- Maintenance of a strong presence on and over the sea to enforce laws, defer conflicts and settle disputes (including under-sea activities).

CHAPTER 8 PROBABLE IMPACT SCENARIO

DEVELOPMENT OF SCENARIO

The methodology, logic, definitions and assumptions used in developing the Low Impact scenario are applicable to all of the scenarios discussed. Data were not available to allow quantification of impacts according to water scarcity; therefore, the impact of water scarcity was evaluated in terms of the response elicited. This approach permits impact evaluation regardless of whether the water scarcity problem is severe, moderate, or low, i.e., unorganized, unplanned, or counterproductive: a response could result in high impact even though the water scarcity was, in fact, neither severe nor moderately so.

In the Probable Impact scenario, planned responses to increase supply are adopted while efforts are exerted to modify demand. Technological innovations are implemented to increase supply while more rational forms of balancing supply and demand are worked out. The impact to the Coast Guard is primarily due to the reliance on the ocean for this increased supply; icebergs and desalination, offshore energy production, and ocean minerals mining. All of these remedies involve considerable expense and planning. All impact the U.S. Coast Guard but its actions are planned and conducted in concert with those of the Federal and state regions. Simultaneously improved agricultural management practices, coupled with reuse and recycle,

use of conservation devices, and, perhaps use of treated wastewater (direct or indirect for aquifer recharge) occurs. These actions are accompanied by a compaign of awareness to both corporations and individuals as to the severity of the occurrence and the options available to remedy the situation. Voluntary citizen and industry support is obtained.

ROLE OF GOVERNMENT

Control and Allocation of Resources

Government provides resources in the form of funding, total, partial, matching and also its resources in technical and legal areas. It uses its access to the media to inform the Nation of the problems involved, progress being made, goals to be achieved and guidance in reaching those goals.

Relationship of Units of Government

As in the case of the Low Impact scenario, the relationship of units of Government remain essentially unchanged. Activities in their respective areas of responsibility will intensify but relationships will remain the same.

CANDIDATE TECHNOLOGIC ADVANCES LIKELY TO BE IMPLEMENTED

Candidate technological advances likely to be implemented are listed in order of their likelihood of implementation:

- Shore-side desalination (conventional, nuclear, solar-powered)
- Water reuse and recycling by both industry, agriculture and aquaculture

- Offshore desalination (conventional and solar-powered)
- Onshore solar energy production
- Offshore mineral mining
- Offshore energy production

ROLE OF U. S. COAST GUARD

As indicated above, the responsibilities specified in the defined USCG mission will remain the same, but the intensity of the activities required to fulfill the mission elements will increase concurrently and in concert with the activities of the other involved organizations, governmental and industrial.

CHAPTER 9 HIGH IMPACT SCENARIO

DEVELOPMENT OF SCENARIO

National Disater

National disaster might occur as a result of a rapid succession of nuclear power plant disasters which would effectively poison the population, the earth, surface waters and at least some ground waters. The same results could accrue from a saturation nuclear attack. An armed political revolution could lead to disaster and/or anarchy of uncertain duration, wherein all organized government functions would cease. Natural phenomena of nationally disastrous proportions would not occur in such a short period of time that organized planning and plan implementation could not obviate or mitigate the effects.

International Disaster

World Wars I and II were awesome and certainly resulted in some large disaster areas wherein government functions were indeed disrupted for varying periods of time. A third World War could bring disaster on an international scale but the precise nature of the effects and their ramifications is not understood.

International Confrontation

International confrontation, similar to national and international disaster is difficult to define regarding

affects. Short of widespread destruction, pollution or poisoning of water supplies and complete disruption of government activities/leadership, the most conceivable result of each situation is the sabotaging of water supplies. These acts, however, would be isolated, small scale, and their effects local in nature. The effects of such activities would not be in any way comparable to the effects of today's use/depletion of the Nation's water supplies by our own people's, industries', and agriculturists' activities. Therefore, this kind of local effect is not incorporated in the scenario. The severity of impact remains defined by the response.

In this, the High Impact scenario, unplanned and uncoordinated responses occur, primarily by sectors of the economy or by regions of the United States. Food and energy supplies will be required. To maintain adequate supply (and perhaps exports or trade), available water supplies are consumed and a trend toward greater reliance on ocean resources develops. In this scenario, the Federal, state and local governments respond to individual problems rather than anticipating and providing necessary direction. The probability of this scenario occurring is low since it contradicts present Federal policy and ignores the large degree of planning currently underway.

ROLE OF GOVERNMENT

As stated above, the likelihood of this scenario is very low and the nature of the disruption is undefined. It would, therefore, be difficult to postulate changes in structure

and mode of operation of government. Furthermore, conditions envisioned in this scenario would not be suddenly manifested, but would develop over an extended time period during which the role of government would change as the various aberrations in the planning and implementation processes appeared.

CANDIDATE TECHNOLOGIC ADVANCES LIKELY TO BE IMPLEMENTED

In the event of this scenario, wherein responses to emerging problems of water shortages are met by bursts of uncoordinated planning and implementation activities, it is likely that any advanced technology such as weather modification, which appears appropriate for solution of the local water shortage problem will be tried.

ROLE OF THE U. S. COAST GUARD

In this scenario, effective fulfillment of the mission of the USCG, particularly in the areas of ensuring safety and of law enforcement, would probably be seriously hampered by the general inadequacy of advance planning and coordination and by widespread disorganization.

CHAPTER 10 CONCLUSIONS AND RECOMMENDATIONS

FINDINGS

There is a significant problem regarding the availability of supplies of fresh water needed to maintain the Nation's progress and livelihood. The problem is being mitigated through stepwise implementation of technologies on a local basis, e.g., desalination of sea and brackish waters and reuse and recycling of withdrawn waters. Wide ranging programs for water conservation are, however, not in effect. The outlook for the next twenty years indicates that this problem will become more severe, but not catastrophic as population, urbanization and industrialization increase and that the problem will be further exacerbated due to the necessity for development of new energy sources. With regard to government policy:

(1) Major Federal policy reform occurred in 1976 and again in 1978.

(2) Those policy changes are consistent with the nature and extent of water supply problems anticipated by the WRC through 2000 AD.

(3) Federal programs, under the reformed policy, are oriented toward better local-State-Federal planning and analyses of water supply problems with emphasis on cost-effectiveness and environmental effects.

(4) Federal, State and local policy encourages conservation as the primary mechanism for extending available supplies.

(5) Real growth in Federal expenditures for water resource projects throughout the year 2000 AD appear consistent with the projected extent and nature of anticipated water supply problems.

(6) Policy changes at the Federal level affect the degree of involvement and the role of State and local governments. This type of partnership will grow due to the localized nature of projected water supply (and pollution) problems.

CONCLUSIONS

It is likely that future Federal water policy changes would include the following guidelines:

- Water resources will be developed in such a way and at such times as will assure their optimum use. This necessarily will involve the concept that each project must be economically sound.
- Public participation will greatly increase in water resource development.
- Local and regional drainage areas would be among the primary considerations to the development of water resources.
- Water resource conservation, education and research as a means to accomplish certain economic ends would receive greater attention and increased funding.
- Primary responsibility, such as the basic decision for water resource development, may be transferred to local, state and regional levels, while Federal responsibility is likely to involve areas of special responsibility and competence.
- Steps to facilitate resolution of controversies surrounding Federal reserved water rights and Indian water rights.

Other findings are as follows:

- Generally in terms of surface water, there is more than an adequate supply for all demand; however, there are localized and even regional shortages due to distribution and pollution.
- The situation is similar for groundwater supplies, except in some regions waters are being withdrawn and consumed at a rate that greatly exceeds recharge.

- The transfer of water (ground and surface) from water rich areas to regions of scarcity is logical but discouraged due to water rights, environmental issues, economics and public attitudes. Federal policy discourages such projects.

- Technological innovations to extend water supply other than by desalination processes are not yet feasible. Most technologies are in the experimental stage.

- Technological innovations to decrease demand and consumption exist, are fostered by pollution control legislation and by present federal policy (as well as funds from federal agencies responsible for policy implementation).

- Thirteen regions of the United States are expected to experience a water supply problem over the next twenty years.

- Examination of forecasts of industrial, agricultural, energy, domestic and recreational activities, in these thirteen regions, all reveal growth, with no tradeoffs between growth activities in any one region being demonstrated.

- Competition among growth activities for scarce water resources will occur.

- Regional problems of competition, including state and local community problems, will be solved at the regional, state and local level. Federal policy and pollution control legislation encourages this approval.

- The role of the Federal Government and its agencies is to foster and assist local problem resolution.

- Population changes and job or skill modifications are not expected to be significant because of anticipation and resolution of problems at regional, state, or local levels.

- Water scarcity issues will affect USCG Headquarters and districts.

- Eight of the 12 existing districts are affected.

- With the exception of three basins (Great Basin, Pacific Northwest and Caribbean), jurisdiction is shared, typically, by two U. S. Coast Guard districts.

- Headquarters would have to provide guidance sufficient to permit multiple district or "lead" district involvement with regional water scarcity assistance.

- Both USCG Headquarters and Districts could be involved in any regional water scarcity problem resolution.

- The USCG has over the years maintained a relatively stable position within the U.S. water resources effort, even with decreasing position relative to R&D, a decreasing budget authority (in real terms) and an increasing responsibility. However, this has resulted in the Coast Guard spreading too thinly for its various missions.

RECOMMENDATIONS

The U. S. Coast Guard should maintain close liaison with all government units involved in water resource augmentation planning in order to be responsive to those inland-waterway, coastal, and off shore activities that are related to efforts to increase water supplies and energy production. Paramount will be the allocation of sufficient funding for the U. S. Coast Guard to expand certain of its operational capabilities as needed.

The U. S. Coast Guard should review its generic mission in terms of regional and budget priorities as well as its operational and regulatory missions. Where possible, interaction and involvement with regional jurisdiction (via USCG District Offices) currently involved in planning for present or anticipated water scarcity situations should be increased.

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